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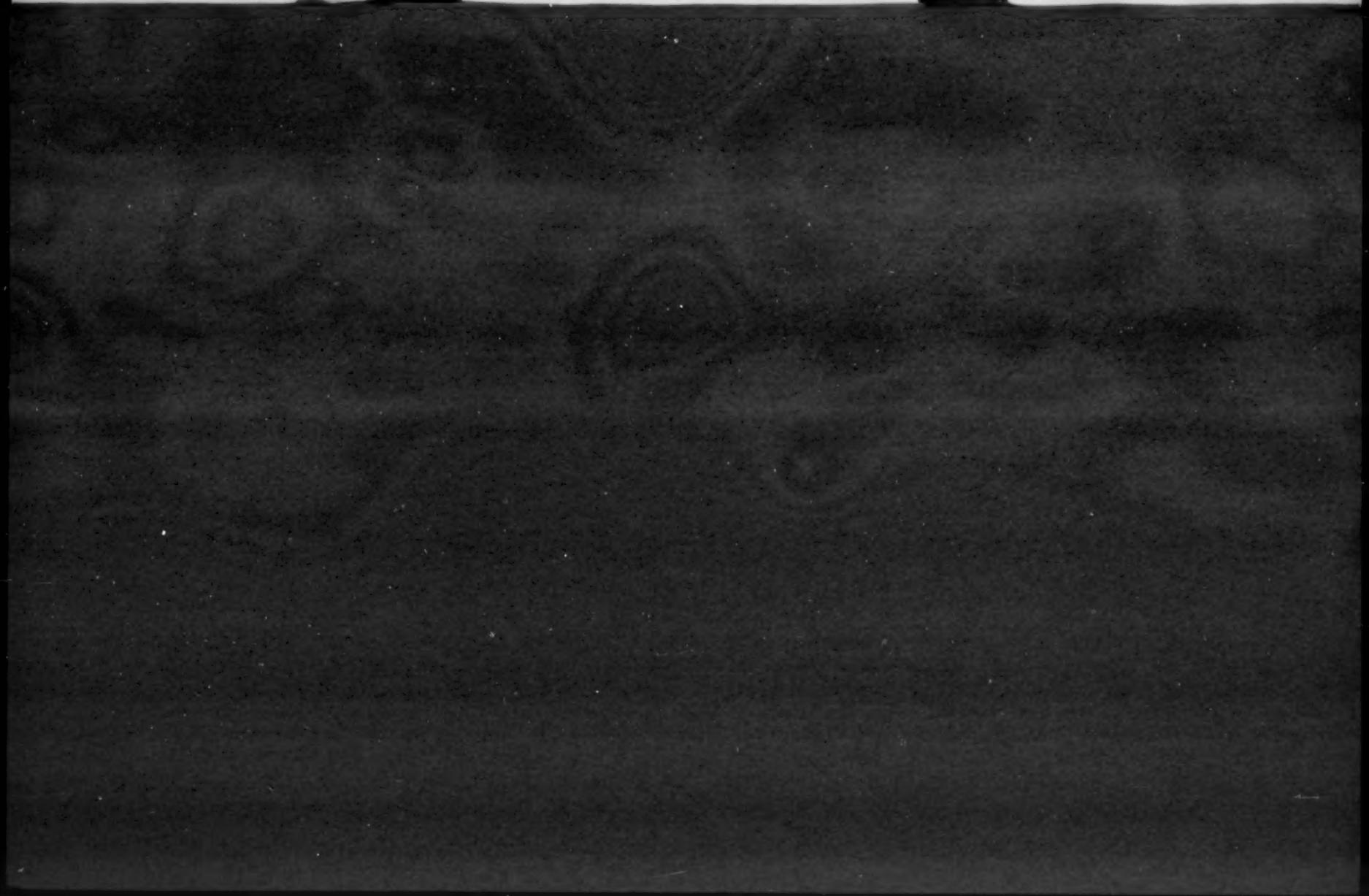

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AND A RECORD OF PROGRESS

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Some Financial Problems of Foreign Telephone Systems

A FEW months ago, there took place in France a series of public meetings, held under the auspices of the President of the French Republic, during a period designated as "Posts, Telegraph and Telephone Week." Opportunity was given at this conference for users of the communication systems of the country to voice their criticisms of the services, and to advance suggestions for their improvement. The telephone system, in particular, was the subject of severe criticism, not only from telephone users, but also from responsible government officials. It was asserted that the toll lines are so unsatisfactory as to be hardly a factor in communication in France. Some of the speakers declared that the telephone, although an instrument of everyday use in the United States, is an item of luxury in France and of very restricted value to the subscriber. Telephone service in the rural districts was described as still in its infancy.

The conference endorsed several constructive proposals. It suggested that the French government, which has had a monopoly of the telephone service throughout France since 1889, should permit the development of telephone facilities in the country districts through small cooperative companies. It also gave hearty support to

a plan which the government had placed before the French Parliament for the expenditure of 200,000,000 francs per annum, for 10 years, on the development and extension of the telephone service throughout the Republic.

Instead of authorizing the expenditure of 2,000,000,000 francs during the next 10 years, however, Parliament, in the Budget Act of June 30, 1923, has adopted a preliminary program for the investment of only 700,000,000 francs on telephone improvements, etc., during the next five years. Moreover, Parliament has specifically reserved the right to fix by annual budgetary legislation the sums which may hereafter be borrowed by the Department of Posts, Telegraphs and Telephones for purposes of general construction. Officials and others interested in the development of the French telephone system have long been urging the importance of such financial provision as would make it possible to plan ahead for the systematic improvement and extension of the system over a period of years, to meet adequately and economically the growing demand for service.

The Need of Long-Term Planning

The fact that careful and intelligent long-term planning is peculiarly necessary in the telephone business has been recognized in the United States practically from the beginning of commercial telephony.

In 1878, when there were only two or three primitive telephone exchanges in operation, Alexander Graham Bell foresaw the time when a network of telephone wires would stretch from building to building and from city to city, so that "a man in one part of the country may communicate with another in a distant part." Mr. Bell urged upon prospective investors in telephone securities "the advisability of keeping this end in view, that all present arrangements of the telephone may be eventually realized in this grand system." From that day to this the development of the Bell Telephone System in the

United States has been consciously guided by a spirit of foresight, which has directed every effort toward the creation of a universal service, capable of systematic and well-balanced expansion to meet the growing needs of the public.

The Budget Plan of the Bell System

In the Bell System the work of planning ahead has always been recognized as fundamental and has been organized on a highly scientific basis, until now a comprehensive five-year Budget is prepared annually which forecasts future operating and financial results and requirements in the light of the ascertained facts and tendencies of past experience, and furnishes a sound basis for a coordinated administrative program covering the succeeding five years.

In the preparation of this Budget, account is taken of expected general economic and financial conditions, of the probable future volume of business activity as a whole, of the prospective movement of general wage levels, employment conditions, interest rates, and other external factors which have an influence upon the telephone business. The probable increase in population and its distribution in cities, towns, and rural areas is carefully estimated. Surveys are made of the various classes of telephone service that may be offered to the public, and forecasts are prepared of the revenues that each class of service may reasonably be expected to produce. Painstaking estimates are compiled of the equipment and personnel that will be needed, based on studies as to the best and most economical technical and commercial practices. Detailed studies are undertaken, not only of the plant facilities that will be required to meet the needs of the five years immediately ensuing, but also of the "backbone" plant which must be provided during that period in order that the System may be ready to serve expeditiously and economically the larger requirements of the more distant future. In this connection it is frequently

necessary to look ahead far beyond the five-year period embraced in the formal Budget, and to forecast as accurately as possible the needs which may be expected to develop in ten, fifteen or even twenty years.

The final step in the preparation of the Budget is the translation of the program envisaged by it into terms of new capital requirements. With these requirements thus carefully determined, a well-balanced program of financing may be arranged which will assure that new funds will be available when required in adequate volume and upon economical terms. With such a well-balanced financial program, advantage may be taken of favorable market conditions for the flotation of new security issues, and the purchasing of materials and supplies may be adjusted to price movements so as to realize the greatest possible economies in this direction. It is obvious, of course, that no scheme of scientific prevision, no matter how carefully prepared, can have any considerable value if the administrators of the business cannot command the financial resources necessary to carry it out.

The Constant Need of New Capital

An adequate telephone service cannot be developed in any modern community without the continual investment of large amounts of new capital. In the United States, where there is already one telephone for every 7 people, the demand for telephone service not only continues unabated, but is even increasing. Every expansion of the service gives rise to demands for still further extensions. In Great Britain, where there is only one telephone for every 47 persons; in France, where there is only one for each 76 of the population; in Germany, where there is but one telephone for every 29 people, the potential demand for telephone service is immense. In every country the telephone system must constantly expand, if the normal increase in the public's requirements is to be adequately supplied. New telephone instruments, new switchboards and other central office equipment,

new pole lines and cable must continually be furnished, and can be provided adequately and promptly only by the expenditure of new funds in considerable volume.

Moreover, the supply of new capital must not only be adequate; it must also be dependable. If comprehensive plans for future development are to be not only formulated, but actually put into operation, it must be possible for telephone executives to be certain that the money necessary to effectuate their programs will be available promptly as required. It is important that when the need for quick action arises, it should be possible for executives to go ahead without being hampered by lack of funds.

The Need of Adequate Accounting

While adequate financing thus contributes largely to the proper development of telephone service, it is obvious that a telephone enterprise must, to be efficient, keep systematic records of all its financial transactions; and that these records should be maintained in accordance with sound accounting practice. A capital account should be set up, and all current expenses and fixed charges arising out of the operation of the business, including adequate provision for depreciation, should be recorded as an offset to current revenues. All this might appear to be too elementary to warrant mention, were it not that in many countries adequate accounting methods have not been employed by those charged with the preparation of the financial statements of the government-owned telephone systems. Even in Great Britain, where the accounting system of the government's wire services has been very much better than that used in some other countries, the Parliamentary Select Committee on the Telephone Service in 1922 felt impelled to recommend that "the Post Office telephone accounts should be kept in a more commercial form, and more extensive use should be made of a capital account." During the past year the British Post Office, though handicapped by having four

different Postmasters-General within seven months, has been making an earnest effort to put into effect the recommendations of the Select Committee.

The Need of Continuity in Administration

This matter of frequent changes in the responsible head of the service is, indeed, one of the principal difficulties with which governmentally operated telephone systems are forced to contend. Cabinet ministers are frequently either promoted or shelved for political reasons having nothing whatever to do with the conduct of their departments. It was pointed out years ago by a Royal Commission investigating the postal, telegraph and telephone systems operated by the Australian government that, under such circumstances, ministers are apparently anxious to signalize their occupancy of office by some new and distinct act of administration. The tendency of new Postmasters-General to make sweeping changes seems to have been corrected in the Australian service following this report, for another investigation five years later disclosed the fact that new incumbents had apparently not interfered very much with the working of the department. The official investigator, however, reported that the very fact that a new chief had the power to make changes resulted in the department's marking time until it was ascertained what his ideas were.

Another instance of the unfortunate effects of frequent changes in administration is found in the telephone service of France, where not only have the heads of the Department of Posts, Telegraphs and Telephones been constantly changing, but the form of organization itself has been frequently altered.

Conditions such as these practically preclude the carrying out, even if they do not always prevent the formulation, of far-reaching plans for telephone development and financing. Yet where the telephone service is a government monopoly the party in power is responsible to the public for conducting it, and must, in common political

fairness, be allowed to select the administrative head and to shape the policies of the department. When the opposition comes into office, however, it is not strange that its first act is frequently to discard the policies and programs of the party which it has been consistently opposing and has finally displaced. Such action may well be based on the belief that success in the election constitutes a popular mandate to effect signal alterations in governmental policy. Failure to distinguish between questions really involving governmental policy and questions of ordinary business administration, is unfortunately common enough to constitute a serious obstacle to the effective operation of telephone systems under government ownership.

Outside Control of Telephone Financing

The executives of government telephone systems have frequently to contend, however, not only with lack of continuity in administration, but also with the even greater handicap of inability to secure adequate funds. Thus the history of the telephone in France was summed up some years ago in a report to the Chamber of Deputies as "the story of successive programs, very brilliantly conceived, but never realized for lack of resources."

The report in which this statement was made, was presented to the Chamber in 1910 by Deputy M. T. Steeg, who pointed out that dependence on annual appropriations, frequently inadequate for new construction, had greatly restricted the development of the French telephone system. He strongly urged that the telephone administration be authorized to float general loans, to use the proceeds on such construction for capital account as it might think best, and to amortize the indebtedness out of earnings during the life of the plant so constructed. As recently as last winter, Monsieur H. Milon, Chief Engineer and Director of Telephone Operation, declared that the principal reason for the inferiority of the French telephone service was the lack of any systematic or

coordinated plan in the building up of the system. He suggested that the administration be permitted to carry out a real development program, which should not be subject to the vicissitudes of yearly budgetary manipulation.

Although repeated efforts to secure the passage of the legislation suggested in 1910 have been made during the thirteen intervening years, it has remained for the present Parliament to take definite action. The Budget Act of June 30, 1923, to be sure, authorizes the Administration of Posts, Telegraphs and Telephones to float loans for construction account; but Parliament retains the right to limit the amount of such loans by annual budgetary legislation.

The dependence of government-owned telephone services upon Parliamentary authorizations is the barrier which has blocked many a well considered program of telephone development. Moreover, this barrier is unavoidable, because it is of the very essence of governmental theory and practice that not a penny shall be spent by a government department without the sanction of a definite legislative enactment.

This theory is perfectly sound. It is designed to protect the public funds from loss through dishonesty, extravagance or errors of judgment on the part of administrative officials. Legislative bodies are perfectly capable of prescribing in a fairly satisfactory way the expenditures required for the maintenance of the executive, legislative and judicial departments of government. This method of financing is one of the very foundation stones upon which governments are built. It cannot be eliminated; and, so far as concerns financial provision for the ordinary functions of government, it would be as undesirable as it would be impossible to do away with it.

This fiscal theory, however, was formulated at a time when governments practically confined themselves to the exercise of strictly governmental functions, and when their business activities were limited to the transmission

of the mails,—a service requiring little plant or fixed capital. The policy of financing by legislative appropriations was never intended to apply to the conduct of business enterprises. It is utterly unsuited to the requirements of a dynamic business. This is especially true of the telephone service, which, by its very nature, requires the constant investment of large amounts of new capital in order adequately to supply the public's requirements. This fiscal practice sharply limits the functions which governments are fitted to perform satisfactorily. It is largely because of this financial handicap that government departments are unsuitable instrumentalities for the conduct of commercial enterprises.

Of course, the details of procedure in obtaining appropriations for telephone purposes vary in different countries and at different periods in the same country. The general characteristics of the system, however, are substantially uniform, and are such as are entailed by the general acceptance of the theory that there must be no expenditure except by specific appropriation. The essential feature of the system is always the same, viz.: that the financing of the telephone system is not controlled by those who are responsible for furnishing the public with adequate telephone service.

Pruning the Estimates

In government-owned telephone systems, the usual procedure in obtaining funds is for the executives of the telephone department to prepare detailed estimates covering the contemplated expenditures for all purposes during the ensuing fiscal year. No matter how carefully these estimates are drawn up, however, they are, in practically every country, subjected to a considerable revision by the financial officers of the government before they are even submitted to the tender mercies of Parliament. It matters not whether the reviewing authority be the Treasury or a Budgetary Committee,—in any case the revision of the telephone estimates is performed by an

official not connected with the telephone department. He is not responsible for providing satisfactory telephone service. He is, however, responsible for keeping general governmental expenditures and receipts in proper relation. When, as is too often the case, capital expenditures for telephone construction and extension must be included in the general budget of governmental outlays, the Treasury is likely to be more concerned with keeping such expenses at a minimum than with pushing telephone development. In some cases it has no choice but to scrimp the needs of the telephone service in order to provide the funds necessary for pressing military, naval or other strictly governmental requirements.

The Chief Engineer of the French telephone system pointed out, in a recent article, that the credits allowed in the budget each year for the construction of new telephone trunk lines have been growing smaller and smaller, and in 1921 and 1922 dropped to nothing at all. He explained that, "as the regulations governing public accounts preclude the incurrence of any expense before a corresponding amount of money is available therefor, it becomes utterly impossible to draw up any rational works program in advance." It is in an endeavor to remedy this situation that the new provisions regarding telephone financing were included in the recent French Budget Act.

This condition, however, has not been peculiar to France. In his annual report for 1918–19 the then Postmaster-General of Australia complained vigorously of the action of the Treasurer in reducing the Post Office Department's "bed-rock" estimates for new telephone construction. This action, the Postmaster-General declared, had placed the department in a very embarrassing position, as its officers were "at a loss to find a suitable excuse to offer prospective subscribers when refusing to provide service for them." He emphasized the fact that the service must inevitably suffer from what he characterized as a "systematic starvation policy"; and pointed out that it had been necessary to adopt unsatisfactory ex-

pedients and makeshifts, resulting in serious loss of revenue and a substantial increase in maintenance costs. Two years after this vigorous complaint, a subsequent Postmaster-General again commented in his annual report to the Governor-General of Australia on the inability of his department to obtain adequate funds for the extension of the telephone service. He asserted that this had seriously hampered the executives in their efforts to overtake arrears and to meet the ever-increasing demands of the public.

In 1922 the Australian authorities made a determined effort to remedy this condition by the adoption of a comprehensive three-year program for telegraph and telephone construction, involving a total investment of £8,498,073. Funds were made available, however, for the contemplated expenditures of the first year only; and, as under the similar French plan, Parliament retains the ultimate control over telephone financing.

Parliament as the Final Authority on Financing

After the preliminary pruning by the Treasury or the Budgetary Committee, government telephone estimates are submitted to Parliament, with which rests the final determination as to the financial provision to be made. Needless to say, the members of Parliament cannot possibly be versed in the intricacies of telephone management; and if they were, they could not afford the time for an adequate investigation of the telephone needs of the country. Nor are they, any more than the Treasury, held accountable by the public for the quality of service rendered by the government telephone system. Yet it is for them to say what shall be spent on telephone development and telephone operation; and here again the need of funds for military and other expenditures tends to reduce the provision for purely business services like the telephone.

Legislative Delays

Another feature of the legislative appropriation system which has proved a serious handicap to telephone executives in many countries, is the tendency to delay.

In some cases the telephone estimates have to be prepared so long in advance that by the time the money is actually made available, conditions have changed to such an extent that the appropriation has become inadequate. As the appropriation must not be exceeded, even under such circumstances, the whole tedious process has to be gone through again. Moreover, in certain countries, the annual appropriations have been made available so late in the fiscal year that they could not be wholly utilized before the end of the year, when the unexpended balance lapsed by limitation. In Great Britain and some other countries, however, "votes on account" are provided, to bridge the gap between the beginning of the fiscal year and the time when the definitive appropriations are finally passed.

Delay in the provision of funds for the purchase of current supplies, as well as for construction account, has involved some government telephone systems in heavy additional expense when purchases have had to be made on a rising market. In answer to a question asked in the Australian Parliament a year or so ago, the then Postmaster-General estimated that the price of telephone equipment for which requisitions had been submitted to the Treasury by the Post Office in 1916 and had been rejected, had since increased by an average of at least 50 per cent. So also in France, even before the financial stringency and price inflation which followed the outbreak of the war, complaint was made in a report to the Chamber of Deputies that the rigidity of the budget prevented the telephone administration from taking advantage of the opportunity to accumulate supplies, such as copper wire and insulating materials, when the market was favorable. It is only recently that an attempt has been made to remedy this situation.

French System of Local Loans

The French administration has long been permitted to supplement the budgetary appropriations for telephone construction by loans obtained from chambers of commerce and similar bodies in the municipalities in which the extension of telephone facilities is contemplated. These loans have supplied funds for some pressing needs; but, as has recently been pointed out by one of the high officials of the French telephone administration, money obtained in this way has had to be spent in the communities which loaned it. This system has therefore served to develop the local networks without furnishing the means for a corresponding expansion in the toll lines connecting them. As the French executive puts it: "The capillary vessels have inordinately increased, due to the lack of capacity in the main arteries, hence the congestion and delays on the large clearing circuits."

Telephone Deficits

The effect of budgetary control over the financial operations of government-owned telephone systems, moreover, is seen not only in stunted or ill-balanced development due to the constriction of capital financing, but frequently, also, in the determination of rates by considerations other than those of a purely commercial character.

Illogical rate-making in government telephone systems has taken various forms. Perhaps its commonest manifestation is the establishment in response to popular demands, of a telephone rate structure which produces revenues inadequate to cover operating expenses, and fixed charges. In this connection it must be remembered that the operating expenses of a publicly owned telephone system are subject to augmentation as a result of uneconomical methods of operation necessitated, in many cases, by causes beyond the control of the telephone executives themselves. Under such conditions, of course, the deficits from the op-

eration of the government telephone system have to be made up out of other governmental revenues. In that case the general taxpayers are in reality compelled to meet out of their own pockets the expense of providing telephone service at less than cost for the comparatively small proportion of the community who are subscribers to the telephone service. In addition, the taxes which would have been collectible from the telephone system, had it been privately owned, are lost to the Exchequer.

Italy, for example, has been losing money on her government telephone system for years; and this is admittedly one of the impelling causes which have led the present Italian government to adopt the policy of turning over the state telephone service to private ownership and operation as soon as practicable.

Nor is the drift toward private enterprise in the field of European telephony confined to Italy. Poland has lately turned over her government telephone system to a company in which private enterprise will have a majority interest. Greece is negotiating for private operation of her national telephones. A similar attitude is manifest in Spain, and even, it is reported, in Soviet Russia. Although the French and British governments have declined to sanction proposals for the restoration of their respective Post Office telephone services to operation by private companies, there has been active agitation for such a move in both France and Britain since the war.

In many countries heavy war debts have intensified popular dissatisfaction with government telephone services which are admittedly run at a loss. Moreover, even in some cases in which it is claimed that net profits are earned on the working of government telephone systems, there is reason to believe that, if really sound accounting methods were applied, notably in the matter of providing adequately for depreciation, net deficits might be disclosed, or at any rate that the surpluses might be reduced.

The importance of keeping telephone accounts on a thoroughly sound basis has already been mentioned, but

it cannot be overemphasized. Absence or insufficient use of a capital account; failure to distinguish between expenditures for new construction and for current maintenance; lack of any adequate provision for depreciation; the keeping of accounts on a cash instead of an accrual basis; neglect to apportion overhead and other expenses among the postal, telegraph and telephone services, when these are operated by a single government department; and sometimes the lumping of the receipts from the telegraphs and the long distance telephones, are among the practices which hamper the search for comparative data on the financial results of government telephone operation in various countries.

The practice of placing both the telegraph and the telephone under Post Office management has had further anomalous results in several countries. For example, even when the financial results of the telephone and telegraph systems are shown separately, the income balance of the department as a whole seems to be regarded as the important thing. In some cases, governments have apparently been content to operate their telegraph systems at a loss for years, provided a surplus was reported on telephone operations which could be used to offset, partially or wholly, the telegraph deficits.

Again, in certain war-impoverished countries telephone rates have been increased, not with a view to meeting the financial needs of the service, but in an avowed effort to increase the general revenues of the government. From the point of view of the general fiscal policy of the state this can, no doubt, be justified as a special tax, but its effect on telephone development must be unfortunate.

"Making Bricks Without Clay"

The really serious results of attempting to finance a telephone service by the governmental system of legislative appropriations are seen, indeed, in the inadequate development of the telephone systems in many countries, which inevitably results in greatly restricting the useful-

ness of the service, even to those who are able to obtain it. It is significant that nothing has been achieved under government ownership approaching the universal service which has given the United States two-thirds of the world's telephones for the use of one-sixteenth of the world's population.

The executives of the telephone systems under government ownership are not to blame for this condition. Adequate telephone development presupposes not merely the ability to formulate wise and far-reaching plans, but also a continuity and freedom of administration rarely found in governmental enterprises, and, above all, the possession of the financial resources necessary to carry out a comprehensive program.

The financial system of legislative appropriations, an essential feature of the fiscal policy of practically every government, precludes effective long-term planning, especially in the case of a continuing service which, like the telephone system, requires the constant investment of large amounts of new capital. To the truth of this statement the gallant, but uphill fight for adequate funds which has been waged for decades by far-sighted telephone executives in various countries, bears eloquent witness. Many of them must have been tempted to exclaim, as did a certain Postmaster-General who had been denied the funds which he considered essential for the development of his country's telephone service: "I have been expected to make bricks without clay for nearly four years. To this there must inevitably be an aftermath."

RICHARD STORRS COE.

Accident Prevention and Allied Work in the Bell System

From the Address of Mr. W. P. Elstun at the American Railway Association, Telegraph and Telephone Section, in Colorado Springs, Colorado, on September 19, 1923.

BEFORE undertaking a description of the Accident Prevention and Allied Work in the Bell System, it seems desirable to briefly outline the extent of the coordinated effort involved in these activities.

There are twenty-five companies associated with the American Telephone and Telegraph Company, comprising the Bell Telephone System. These companies together with their connecting companies cover practically the entire continental United States. Because of its very nature the telephone business requires that its workers be widely scattered. They are not confined to the cities and built up communities. The miles and miles of lines extending throughout the country must be periodically inspected and must be continually maintained. Employees of the System therefore travel not only the beaten trails of humanity but penetrate the remoter sections as well.

The number of employees in the service of the Bell Telephone System is about a quarter of a million, of which some 70,000 are men in the Plant Departments. These are the men who construct and maintain the poles, wires, cables and apparatus and are the force among whom the greater majority of the accidents of the Bell System occur. It is with this force that I deal primarily in this paper.

Accident prevention has been a recognized ever present problem in the Bell System since the very early days of the business. We have always considered it largely a matter of proper cooperation between the management of the company on the one hand and the

general employee body on the other. This is probably particularly true of the telephone business because of the scattered individual employees who necessarily do not work under a constant direct supervision as do the workers of most industrial plants. These industrial workers are often congregated under a single roof with the ever watchful eye of a foreman constantly upon them. The telephone employees working individually or in small groups, as for example the installer who connects the instrument in the new subscriber's home or office are often at a considerable distance from their immediate supervisors. It is therefore obvious that in the telephone business proper teamwork between management and employees is necessary to prevent accidents.

To effect this teamwork it has been our opinion for years that both management and the employee body have certain definite responsibilities to perform and that only through the continuous performance of these responsibilities in perfect harmony and accord can the desired results be accomplished.

Briefly management's responsibilities are:

(1) The careful selection and training of employees.
(2) The provision of tools, materials, apparatus and methods which are safe when used with reasonable skill and care.
(3) The establishment of adequate supervision to insure that the prescribed practices are followed.
(4) The provision of adequate safety devices and the training of employees in first aid.
(5) The provision of ways and means to keep alive the employees' interest in the prevention of accidents.

The employees' part in this cooperation to prevent accidents seemed to resolve itself almost solely in following the methods prescribed with reasonable skill and care and in offering suggestions that might assist.

For years we had worked upon this fundamental principle and our efforts we felt had been rewarded with no small measure of success.

With its continuous development and expansion, however, the telephone business is an ever changing art. What was best yesterday may be modified to advantage for the needs of today or to-morrow. Thus a development took place in connection with the employees' part in this cooperative movement to prevent accidents. They felt that they could aid the movement by preparing safety codes themselves, to cover the individual's personal conduct in so far as it affects the prevention of accidents, and through their own representatives they enthusiastically undertook this work.

There eventually were produced some of the most comprehensive, best illustrated booklets on "Accident Prevention" that I have ever seen.

The details of the procedure followed in preparing the codes differed somewhat between companies because the employees themselves largely worked out the plans. However, in general, the plans were along this line:

> Suggestions were received from all the plant employees and these, together with records of accidents, were reviewed in turn by district and division committees. Finally all of the data from all of the divisions was passed on to a general committee which prepared a single code for the company based upon the experience of every single man in the department.

In most cases these general committees came on to New York with a draft of their code and asked us to review it with them. These reviews were made from the standpoint of coordinating the requirements of the codes with those of Federal regulations and of national associations. Naturally in this whole process of development there were contacts and conferences between the men themselves and representatives of other departments as

for example the engineering department. These engineers who were designing and developing the tools, materials and equipment, through these contacts received some first hand thoughts and suggestions from the men who were using their products and the men in turn received some scientific knowledge regarding the tools and materials which they were using that was helpful to them from an accident prevention standpoint.

The very fact that every single man in the plant department of a particular company had some part in the preparation of his particular company's code aroused a degree of interest on the part of the general employee body in accident prevention that could not have been obtained otherwise. The employee body began to realize as never before the absolute wastefulness of accidents and to appreciate that from the standpoint of the safety and well being of each individual, every man should constantly exercise care and forethought in all of his work.

First Aid

In conjunction with the preparation of these Safety Codes another phase of accident prevention work was undertaken which has in no small measure assisted in accomplishing the results desired. This consists in giving instruction in such features as stopping arterial bleeding, splinting broken bones, resuscitation in case of electric shock or gas asphyxiation, caring for cuts and burns, and making the patient comfortable for transportation. This First Aid training work, before general adoption throughout the system, was given a very thorough trial in one of the Associated Companies. It was found that the added knowledge, making it possible to properly care for an injured employee after an accident was only one of the benefits accruing. It developed that with this knowledge the employees became much more careful and in general, more efficient. The accident rate in the company where the training was tried out promptly began to reduce and this company has con-

sistently had about the lowest rate in the system since the work was undertaken. After training, the employees were grouped into teams of five men each, including a patient. The teams compete in preliminary, semi-final and final contests, so that eventually one team in each division is selected as the most skilled and proficient. The contests are real sporting events and the rooters are just as enthusiastic and interested as any baseball or football crowd that you have ever seen.

Later today you will have an opportunity to see a demonstration in first aid by one of the teams composed of workers right here in the Mountain States Telephone Company's territory. You can then judge how well they are equipped to serve their fellow men whenever and wherever that service is needed. I know that through the newspapers you are all familiar with the kind of work that they are doing so I just cite two clippings that are typical of the hundreds that have appeared from time to time as news items:

> "First Aid came to the fore when a telephone splicer pluckily dove from a pier into the East River to save a man from drowning and then brought him back to consciousness by administering artificial respiration. The splicer is a First Aid instructor in the campaign carried on in the Bell Telephone Company."

Here is another.

> "It was due to the quick thinking of Mr. Blank, a First Aid instructor of the telephone company, that a six year old boy is alive today.
>
> The lad was watching a ball game when he fell on a broken bottle and severed an artery in his wrist.
>
> The telephone man saw the boy being lifted into a car which was to rush him to the hospital. Leaping into the back seat as the car was about to start, Mr. Blank first checked the rush of blood by well directed pressure of his fingers, then without releas-

ing his hold, with one free hand and his teeth he fashioned a tourniquet out of two handkerchiefs; despite the jolting of the car, he succeeded in applying the tourniquet and stopped the flow of blood."

These and similar deeds were performed by some of the army of 50,000 or more trained first aid workers of the Bell System scattered all over the United States. These men are everywhere in their regular vocation, they constantly traverse the city streets, the country roads, and visit the homes, factories and business places of the country. They are provided with the skill to be at the service of the great American public in cases of life or death as well as in the communication service of the nation.

These deeds which have been cited are typical examples of the finest kind of service, that of saving a human life. I don't need to describe to you the increased prestige and standing of these men in their communities; the feeling that they have toward the Company that has assisted them in obtaining the knowledge to perform acts of this character. All of these things are apparent.

First Aid Kits

In conjunction with the First Aid training work, three types of first aid kits were standardized to meet the telephone companies' needs. The type of kit required depends, of course, upon the work to be performed. A large kit is provided for our heavy construction gangs and two small pocket kits, one for the splicing forces and one for the installers have been made available.

In the largest kit practically all of the items are packed in a uniform size of container and are arranged so that any one can be removed without disturbing the others. This makes for easy access and convenient inspection. On each package is illustrated the proper use of the article so that in the event that the First Aider in the excitement of an emergency forgets how to use the article, he has but to refer to the container.

Competitive Feature of Accident Prevention

In addition to the supplying of the first aid kits and the training work in First Aid, another feature assisting in bettering teamwork and in lessening accidents had been the placing of accident prevention on a competitive basis.

To have a standard to determine just what constitutes an accident for competitive rating purposes, it was decided to include only those resulting in one full day or more lost time. All accidents are of course reported but only those involving lost time are considered in the rating. It was found that this was necessary because if all are counted, there is a tendency to avoid reporting the very minor cases. Like any game or sport where the selection of a winner rests upon a score, it is necessary, of course, that the contestants themselves understand and believe in the rating scheme, or it will fail.

In the Bell Telephone System a comprehensive report is prepared for each lost time accident occurring to an employee in the course of employment. It is used by the Associated Companies for supervisory and administrative purposes and a copy of each report is sent on to us in New York so that reviews and summaries of all cases may be prepared and made available for all.

Right at the beginning of the form is this statement: "The object of this report is to supply information to be used in preventing similar accidents in the future," and the employees are now beginning to realize that all of these data are collected so that scientific studies of accidents may be conducted with the end in view of preventing similar accidents. The reports are available for review by the employee committees to assist in their endeavor to prevent a reoccurrence, and in many cases Committees of employees themselves investigate the more serious cases and the reports of their findings are reviewed and discussed with employee groups.

The reports of the lost time accidents sent on to us in New York are reviewed and quarterly summaries

prepared, showing the "big league" standings. The teams making up the big league are the various Associated Bell Companies.

Now in addition to this big league, we have minor leagues; each Associated Bell Company prepares charts and data for the employees showing just how each division, district, etc., is comparing with the others in the particular company in respect to preventing accidents.

A real friendly competition has been established throughout the system to lessen accidents and the results accomplished are shown graphically on the chart on page 237.

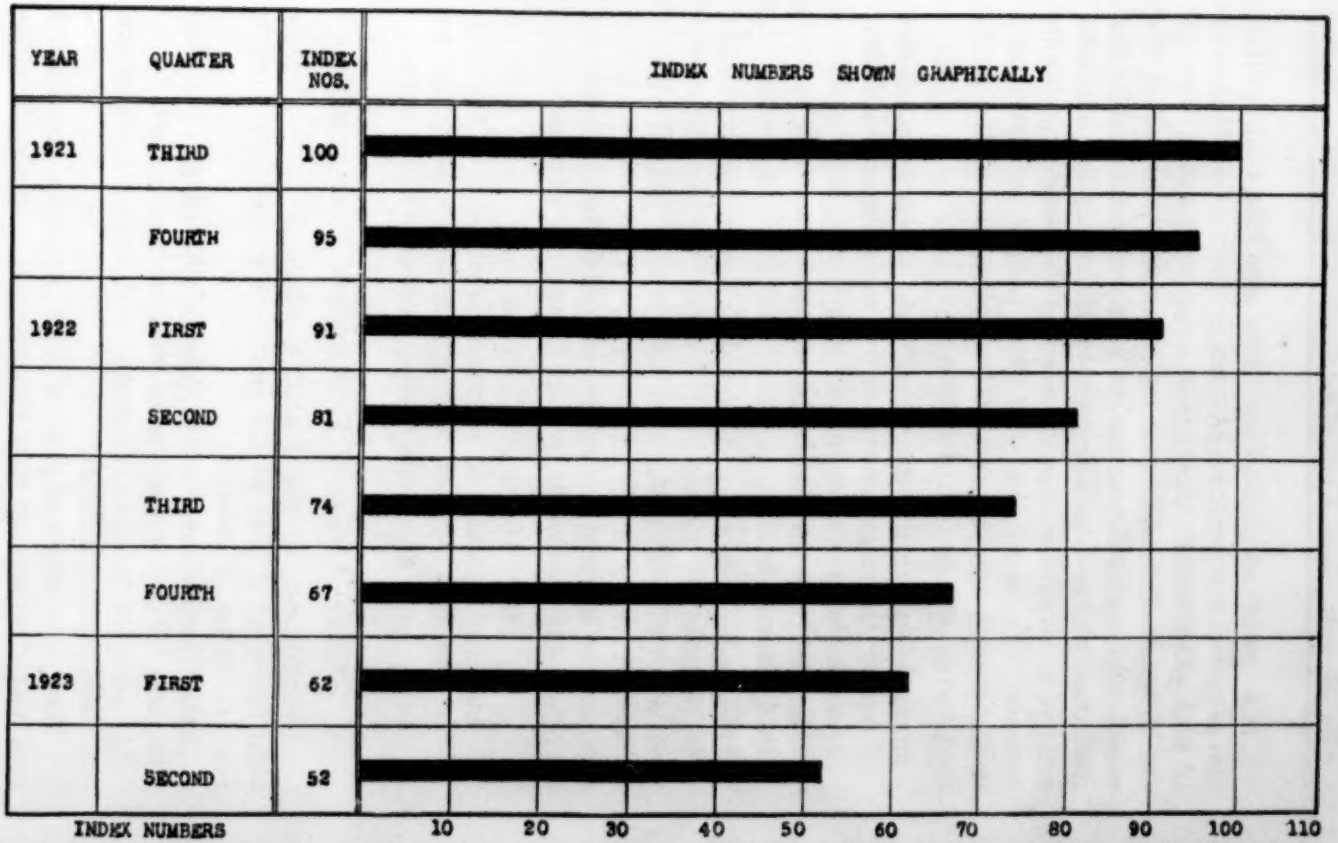
This showing is particularly gratifying when it is appreciated that we started with a comparatively low accident rate back in 1921.

Automobile Insignia

When an industry has established routines whereby fundamental data are constantly at hand for administrative purposes it is a simple matter to promptly keep in touch with changed conditions and to immediately put your finger on weak spots as they develop. The next step of course is to apply remedial measures.

Telephone work is such that tools, material, and men must constantly be transported quickly and safely and as the automobile is the modern short distance transportation medium large numbers of machines are used in the business. In the urban sections of the country with their paved highways and the constantly increasing number of motor vehicles of all character in operation, traffic is day by day becoming more congested and consequently the chance of accidents is becoming greater. As one of the measures to keep automobile accidents at a minimum it was decided to adopt a plan of placing an attractive enameled disc on the side of each car driven throughout a year without a single operating accident. Below the disc, year plates are added, one for each year which is passed without an accident.

REDUCTION IN ACCIDENT FREQUENCY RATE
BELL OPERATING COMPANIES
MAIL PLANT EMPLOYEES



NOTES:—ACCIDENT FREQUENCY RATE FOR THIRD QUARTER 1921 USED AS BASE OF 100. SHOWING IS PARTICULARLY GRATIFYING WHEN IT IS APPRECIATED THAT RATE IN THIRD QUARTER 1921 WAS COMPARATIVELY LOW.

The reactions from this plan are two-fold. First, the plan interests our employees in preventing this type of accident; second, the cars so equipped passing through the cities, towns and rural communities throughout the country bring to the attention of the general public the fact that we, as a public utility, are doing our share to relieve a situation that is rapidly becoming a public menace. To show that our own people are interested in the plan, I cite just one little incident out of the many that have come to our attention.

> A supervisor in one of our eastern companies heard the regular driver of a car warn a fellow employee to whom his car was temporarily assigned not to have an accident because he was out for one of those signs.

In this same company automobile operating accidents were reduced by 19 per cent. in the first year after the plan was put into effect and last year it placed awards on 75 per cent. of all of its cars. That the plan has aroused the interest of the general public has been shown by numerous comments. Here is just one of these:

> A State Highway Commissioner, in a talk on highway conditions, referred specifically to the plan of the Bell System and suggested its adoption by other large automobile using concerns in his state.

Other Accident Prevention Features

In addition to the features which I have already mentioned as a part of the accident prevention work a few others are of interest.

Small handbook inserts briefly outlining First Aid Practices needed in telephone work were prepared.

Guides for talks on First Aid and charts in classroom size were made available.

Then, too, series of posters were prepared, distributed and posted where our men congregated. In the development of these posters, dealing in generalities was pur-

posely avoided. Each poster was designed to forcefully illustrate one particular phase of the work which was a cause of accidents, and the subjects chosen were selected after a careful study of the accident data available. Each is of an educational nature in that it shows first a common unsafe practice to avoid, and second, how the particular operation may be performed safely.

Conclusion

All of these things that have been described to you are but a part of the undertakings of the Bell Telephone System in an endeavor to minimize accidents. If every one of our quarter of a million employees becomes instilled with the instinctive tendency to act with care and forethought not only in their regular vocation but in their homes and upon the public highways, and if each of these employees influences their families, friends and associates to do likewise then we feel that the Bell System has made a most substantial contribution to the general safety movement of the nation.

W. P. Elstun.

How the Telephone Wires Were First Put Underground

An Account of the Earliest Conduit Methods Employed in the Bell System

LET us, in our mind's eye, turn the calendar back forty-two years. It is the last of March, 1881. Mr. W. H. Forbes, President of The American Bell Telephone Company, has just issued to the stockholders the first annual report. It is a little pamphlet of eleven pages, assuring us that the business is satisfactory and that there are upwards of 130,000 telephone instruments in the hands of the Company's licensees throughout the United States. It also shows us that Mr. Forbes and his associates clearly foresee the fast approaching day when the huge frames on the house-tops, and the towering poles on the main streets of the larger cities will suffice no longer to carry the constantly increasing burden of overhead wires. At the very beginning of the business they have inaugurated the Bell System policy of preparedness, for, says the report: "a large amount of work has been done in the electrical and experimental department—— in studying the question of overhead and underground cables."

The wires must be buried, but how shall it be done? Telegraph wires, it is true, have been worked underground for many years, but, back in the Telephone Company's laboratory at Boston, a little band of electrical experts are learning that wires insulated with gutta-percha or rubber, although suitable for telegraphing, cause the telephone to work very badly, so that the voices of one's friends are frequently almost unrecognizable, the sounds being muffled and hollow, and seeming to come up out of the earth. Unexpected difficulties are met at every turn. Speaking of this period, Mr. Thomas A. Watson, Bell's earliest assistant, says, "My recollection of all this work is chiefly characterized by a feeling

of hopelessness I then had. I felt as if I were gazing into an abyss that must be bridged by lives of work and experiment before we could get to the other side."

But the problem of putting the wires in cables must be solved or the business will be stunted. To reinforce its own experts, the Company calls to its aid college professors of physics and of electrical theory. Experiments and tests, carried on with patient, painstaking care, begin to point the way to improvements.

A year goes by and the second annual report of the Company comes to us, saying, "Our experiments in underground cables, while not as successful as we had hoped, have given sufficient promise of satisfactory results to warrant us in undertaking a considerable expense to test the different methods. With this object, we have asked permission to put down cables in Boston, and as soon as the needed consent is obtained, we propose to make careful and thorough practical tests of the best systems offered. There is no strictly underground telephone system in any part of the world, the Paris wires being placed in huge sewers, practically large galleries, entirely altering the ordinary electrical conditions. Foreign companies are apparently waiting to see what is done in America; we have, therefore, nothing to guide us but our own experiments."

Outside of a few installations of the Brooks system of oil-insulated wires contained in buried pipes, practically all that has been done thus far with underground construction is to lay a few short lengths of cable in a wooden box covered over with pitch or asphalt. This has been done in Pittsburgh.

To carry out these underground tests in Boston will be a large and costly undertaking. Preliminary experiments are needed to throw light on some of the doubtful points, and the American Company decides to lay five miles of cable between railroad tracks in Massachusetts for no other purpose than to enable tests to be made. This is an event of importance and the *New York Review*

of the Telegraph and Telephone, one of the leading technical journals of the day, contains a sprightly account of the work.

"Four miles of the cable was ready for laying by Sunday, April 16, and upon that day, at half-past six in the morning, Road Master E. M. Merrill, E. F. Phillips and W. H. Sawyer, the manufacturers of the cable, and H. B. Lytle, of the Telephone Dispatch Company,were on the ground with a gang of twenty laborers, and a locomotive to which was attached a box car open at the rear end and containing the tools to be used.

"The location chosen was the Boston and Providence Railroad between the stations of Attleboro and West Mansfield, and only on Sundays is the road sufficiently free from passing trains to admit of such an extensive operation as the laying of four miles of cable, under the surface of the ground between the tracks.

"It was decided to excavate a furrow or trench for the reception of the cable, and after considering how that might be dug most expeditiously, some one hit upon the happy thought of employing a plow; some men were accordingly sent out to procure such an implement of a farmer; but the first one consulted would not allow his plow to be used on Sunday at any price, and it was some time before one was obtained. Then a heavy beam was lashed to the rear of the car, the plow was chained to that, a man seized the plow handles and the train started up, dragging the rusty share through the closely packed gravel faster than any team which ever was driven a-field. And soon a single furrow five miles in length was opened ready for the reception of the pipe.

"Inasmuch as the cable consisted of numerous sections, each five hundred and thirty feet in length, conveniences were required for connecting together the conducting wires; for this purpose, boxes were prepared into which the opposite ends of each two adjoining sections were run, and when the wires were properly connected, the boxes were made water tight and closed.

"When all the cable thus far received had been properly laid in the trench, an impromptu appliance was contrived with which to cover it up by steam; a stout plank was thrown out from the car at such an angle that when the train moved forward it would draw the gravel back into the furrow like a scraper, so that the cable was buried in a very short space of time.

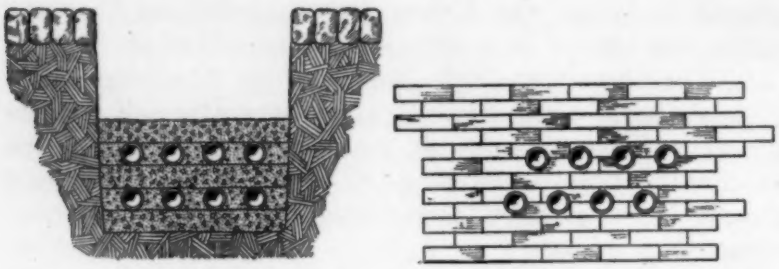
"The remaining mile was laid on the subsequent Sunday with equal success, and the entire job reflects great credit on Mr. Lytle, who has had charge of the mechanical details of laying. The cable itself, weighing nearly 30 tons, filled three freight cars and was constructed as follows:

"Twenty-one conducting wires, ten of which were, besides being insulated perfectly with rubber, covered with tinfoil, which being in permanent contact with the earth through the intermediation of the enveloping pipe, is intended to conduct away any induced currents. Ten others were simply rubber-covered, and twisted together in pairs, while the twenty-first was an ordinary paraffin office wire, No. 13 gauge. The whole of the conductors are enclosed in a leaden pipe, and makes a cable three-fourths of an inch in diameter.

" The experiments with this cable will be performed by the electricians of The American Bell Telephone Company, and it is hoped will set at rest many vexed questions."

Far from encouraging are the tests on this cable, but it is decided to go on with the Boston experiment and to construct, beneath the surface of the street, a system of ducts so that a cable which may "go bad" can be withdrawn and another pulled in to take its place. The general planning of the work is placed in the hands of Mr. J. P. Davis, an eminent civil engineer of extensive experience in the construction of water works, who appoints Mr. W. H. Sears, to act as engineer in charge of the field operations. Great care is taken at every step to ensure the permanence of the work and to exclude

water from the finished structure. Wrought iron boiler tubes, eighteen feet in length and about three inches outside diameter, are used for the ducts. Eight of these pipes are laid in a formation four wide and two high.



Cross Section in Street — As Arranged in Manhole

FIGURE 1

The pipes are spaced three inches apart and are surrounded with concrete three inches thick. In constructing the draw boxes or manholes, a platform of planks spiked to stringers is first laid, and on it, layer upon layer of tarred paper, liberally coated with hot tar, is used to provide a foundation upon which the brick floor rests.

MANHOLES—CONSTRUCTION

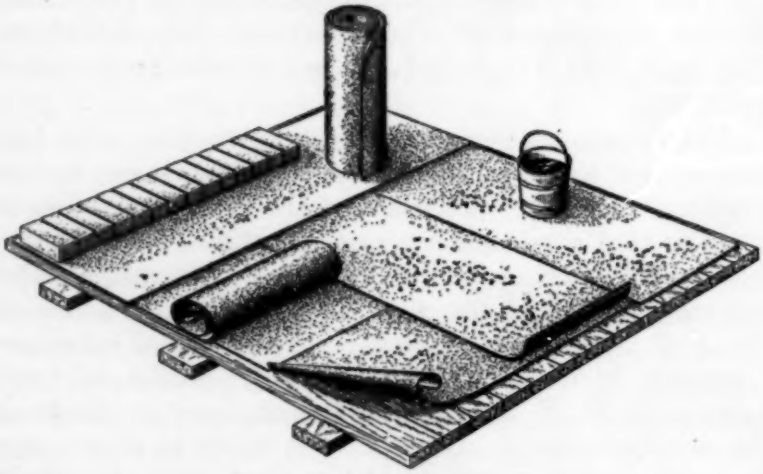


FIGURE 2—Foundation Course

The brick walls are made double and the space between is filled with hot tar. The ends of the pipes are laid to project about ¾ of an inch into the manholes so that, when a cable is to be drawn in, a brass bell may be screwed on to give a smooth rounded surface to draw over, thus preventing injury to the cable from the sharp edge of the pipe.

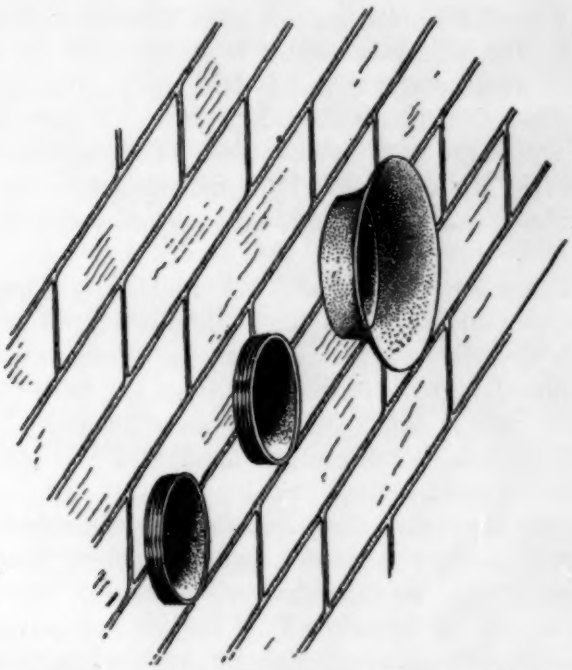


FIGURE 3—Brass Bell to Prevent Injury to Cable

As many as three cables are drawn into a single tube. Although the cables are only about a quarter of a mile long, they seriously affect the clearness of speech when talking through them from stations in the city to suburban points. The duct system in which the cables are placed is, however, a successful job.

We now witness scores of inventors directing their ingenuity to devising all sorts of schemes and plans for

placing wires underground and, in many places, the removal of the poles from the streets is being ordered without regard to the difficulties of talking over wires in cables, as yet far from being solved, thus adding man-made troubles to those imposed by the laws of Nature.

The youthful industry does what it can to meet the demand for removing the wires from the streets and house-tops. The year 1884 has come. At Washington, D. C., a ditch eighteen inches square and half a mile long is dug in the sidewalk and a board trough eight inches wide and of an equal depth is laid in it. At the bottom of the trough six cables are placed. Above these are fifty wires, some of them bare, and at the top there are ten electric light wires. Hot asphaltum is poured in, surrounding the wires and cables and forming a solid mass.

In Brooklyn, the New York and New Jersey Telephone Company has laid six Callender cables in the immediate vicinity of the exchange. They all run together about eight hundred feet from the exchange, then open out into a "Y," three cables running about one hundred feet to Washington Street and the other three to Fulton Street. Each cable contains fifty wires of No. 20 copper and is about one and a quarter inches in diameter. A light sectional iron trough is placed in a trench excavated to a depth of about thirty inches below the paving of the street. This trough is equipped with "insulite" bridges, about eighteen inches apart on which the cables rest. After the cables are laid, vulcanized bitumen—or "Bitite"—is run in so as to cement cables, bridges and trough into a solid mass.

Another year passes. It is the fall of 1885. Progress has been made in getting wires underground for short distances in the cities and in the entire Bell System there are upwards of 1,200 miles of wire underground. Let us inspect the underground plant recently completed in New York City. At the Thirty-ninth Street Exchange, lead covered cables, the wires insulated with cotton and

embedded in paraffin, are used. As these cables are placed in creosoted wooden boxes filled with sand, they cannot be drawn out of the conduits. Each cable contains from fifty to 100 wires. Five cables run from the exchange, through 39th Street to the corner of Seventh Avenue; three through Sixth Avenue to the corner of 42nd Street; and one to the corner of Sixth Avenue and 45th Street.

At the Twenty-first Street Exchange, the Edison system of underground wires, made by the Electrical Tube Company, is in use. There are from 100 to 270 wires in each cable. Each wire is covered with a cotton braiding treated with an insulating compound. All the wires are bunched together and placed in an iron pipe, into which asphaltum is forced, entirely surrounding the wires. The sections of iron pipe are each thirty feet in length, two sections being connected together before laying. The pipes are painted with tar and are laid four feet under the surface with a board placed on top to protect them.

The Spring Street Exchange has a Brooks System made by the Electrical Construction and Maintenance Company of Philadelphia. The wires leave the office in two 4 inch pipes, containing 380 conductors each, and are carried on, through pipes of various sizes down to 2½ inches, to the several points where the wires are distributed on the poles. There is a cotton covering around each wire and the whole number of wires to be contained in each pipe are made into a cable. After the pipes were laid in the street, three feet underground, the cabled wires were drawn into the pipes. Then the pipes were filled with oil. The pipes rest in a wooden conduit into which pitch was poured until the conduit was filled.

Across the river in Brooklyn we find a "drawing-in" duct system constructed of creosoted wood. This was begun in 1884. The conduit is in the form of a square box, the sides, top and bottom of 1½ inch plank, sub-

divided into ducts varying in number from ten to four, the divisions being made with one inch boards. As the manholes are not very frequent it was anticipated that trouble might be experienced in drawing in the cables. To obviate this the ducts are made three inches high by two wide and rollers are placed permanently in the bottom of each duct for the purpose of lessening friction. The conduit was made up in sections of 16 feet which were carted to the trench, dropped in, joined up and the covers screwed on.

The year 1886 arrives. The annual report again gives us a concise picture of the underground situation: "The removal of open wires from house-tops to overhead cables and to underground conduits has continued, the progress in the latter respect being especially encouraging. The system must always be a mixed one, as the final distribution of wires to the customers, and the method of reaching places where underground work would be too costly, must still be overhead; but we think that, within a few years, in all large cities the open wires will be placed in cables above or under ground to such an extent, at least as far as telephone companies are concerned, that the overhead wire nuisance will no longer be serious. In New York an amendment to the law which ordered all wires in New York City and Brooklyn underground before last November, was adopted, establishing a Commission for each of these cities with power to supervise the execution of the law, and to arrange for placing the wires underground to such an extent as might be found practicable. In Brooklyn the Commission has permitted the wire companies to begin their work, and 134 miles of underground wire have been placed there by the Telephone Company. In New York the Metropolitan Company, in August, 1885, filed with the Commission the necessary plans and statements for an underground system, and applied for permission to prosecute the work, but so far without success, and this work in that city is at present at a standstill."

At about this time we find several of the Associated Companies making a trial of small amounts of Dorsett Conduit, made of a mixture of asphaltum and sand.

FIGURE 4—Dorsett's Underground Conduit

This material is moulded under high pressure, while hot, into cylindrical sections three feet in length, and ten inches in diameter. Each section contains seven 2 inch holes which are made to register when adjacent sections are joined together. The year 1886 witnesses five miles of this kind of conduit being constructed under contract for the Telephone Company in Brooklyn. In 1887, after an experience of only about a year with it, Mr. Sargent, the General Manager of the New York and New Jersey Telephone Company, tells us that "The Dorsett Conduit, five miles in all connecting Brooklyn and Williamsburg, when completed proved to be very defective. The faults in it are due to several causes, but chiefly to carelessness in laying it in the ditch and making the joints. After a great deal of work, occupying all this year, the ducts are now reported ready for occupancy. The Dorsett material is very rough, and at the joints it squeezed through the cracks, making projections that were broken off in the process of clearing out, and brushes had to be run through to clear these pieces out. Even now the ducts are so very rough that a lead cable is badly scratched in hauling in. It was claimed this material was gas-tight; our experience is that it is neither gas-tight, water-tight, or even mud-tight, all of these things having been found in the ducts and manholes. The only explosion of gas we have had in Brooklyn was in a Dorsett manhole."

In Chicago, in 1886, we find, in the central district of the city, an underground route about a third of a mile in length, consisting of Patterson and Kerite cables drawn into Dorsett Conduit. Most of the wires in the business district are in cables passing over the roofs of buildings. In the north, west and south divisions of the city, however, where there are exchanges of about 600 subscribers each, there had been installed, the year before, underground cables reaching from a thousand feet to a mile away from the office. About 1,100 feet of conduit, consisting of 16 wrought iron pipes 2½ inches in diameter and laid in concrete, is being built to carry the cables from the existing central office to a new building.

In 1887 the mileage of wire underground in the Bell System reaches a figure nearly double what it was the previous year.

The annual report for 1887 says: "It will be noted that the number of miles of wire underground has materially increased, and we expect further large additions to the underground mileage in the current year, especially in New York, where the Subway Commission has made arrangements for the working of an underground system, which will meet the requirements of the wire companies.

"The legality of the plan adopted by them has been questioned in the courts, and further legislation may be needed before the work can be completed; but, as there is a strong public desire for the burying of the wires to the greatest practicable extent, the necessary legislation will probably be obtained and the work go forward. This will involve a heavy outlay by the Metropolitan Telephone and Telegraph Company, and the subject has been under careful consideration by the directors of that Company and by our Mr. Davis; and they are prepared to put a large part of their wires into subway conduits as soon as the obstacles referred to are removed."

This underground installation in New York City is designed on the principle of keeping the electric light and power wires in subways on one side of each street, and

the telephone and telegraph wires in subways on the opposite side of the street. A special feature of New York subway difficulties is the steam heating underground system of which the leaks in certain localities greatly interfere with the ducts and cables, precluding the use in such places, of materials of construction which melt or soften at temperatures of about 160° to 200° Fahrenheit.

The work accomplished up to September 1, 1888, is shown in the accompanying table:

Character of Ducts	*Feet*
Dorsett ducts, coal tar concrete	235,800
Zinc tubes, laid in hydraulic cement concrete	68,900
Creosoted wood tubes	167,200
Cement pipe, laid in hydraulic cement concrete	216,600
Iron pipe, laid in asphaltic concrete	131,300
Iron pipe, laid in hydraulic cement concrete	1,423,700
Iron distributing pipe	23,300
Edison iron tubes	222,800
Total length of single duct	2,489,600

The size adopted for telephone ducts is 2½ inches clear inside diameter. The manholes are all of brick, laid in cement mortar, with 8 to 12 inch walls and concrete bottoms. The street casting used has a double cover; the inner cover and rubber gasket are held down by a wrought iron cross-bar, a bolt and a padlock. The covers are practically tight against water.

The year 1889 witnesses most of the telephone companies that are putting down subways using 3 inch ducts instead of 2½ inch. In some cases creosoted wood conduits have been made using several horizontal layers of treated wood. In this type of construction the bottom layer of wood is fluted on its upper surface, intermediate layers are fluted on both their upper and lower surfaces and the top layer is fluted on its lower surface so that, when assembled in the trench, they form a square or rectangular structure with round holes for the cables. This is known as the Macdonald conduit.

Use is being made of creosoted wood conduit in the form of individual ducts, called "pump logs," each piece

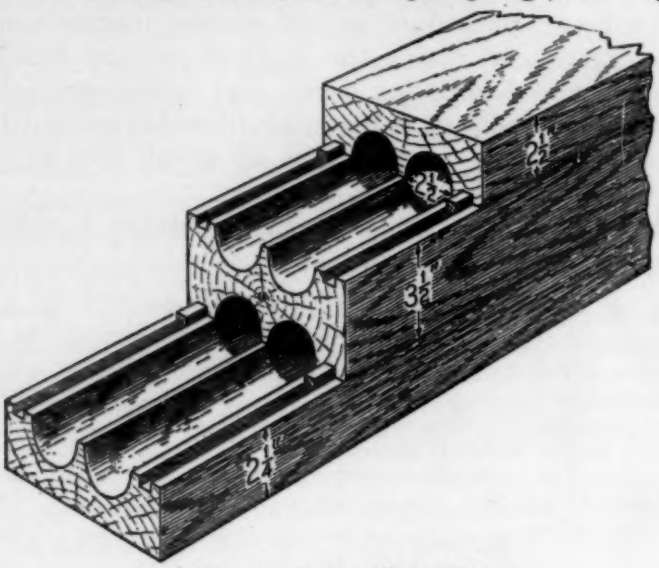


FIGURE 5—Macdonald Conduit

about 4½ inches square with a 3 inch round bore. These are laid, as many as may be required, and in any desired cross sectional arrangement as to width and height.

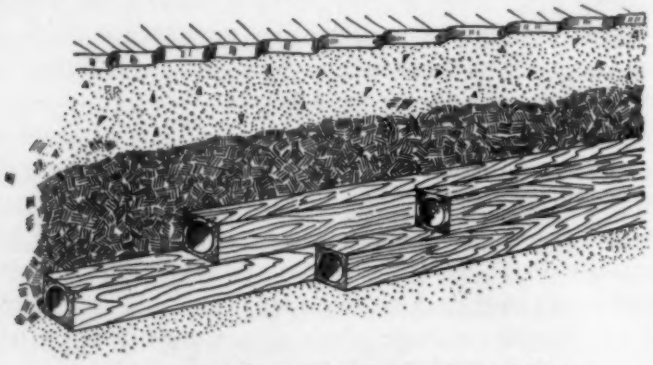


FIGURE 6—Method of Laying Creosoted Wood Ducts

Considerable use is being made of ducts constructed of sheet iron pipe lined with a coating of cement.

Vitrified clay or tile is coming into use. This conduit is made in sections ten inches square divided by a horizontal web or shelf into upper and lower rectangular compartments, each intended to provide space for three cables placed side by side.

About two or three years later conduits begin to be built of another form of vitrified clay, known as hollow brick. The material comes in pieces about a foot and a half long and four and a half inches square with a round hole about three inches in diameter to receive the cable. These hollow bricks are laid with cement mortar and the entire structure is then surrounded with concrete.

Another form of vitrified clay, called the multiple duct soon comes into use.

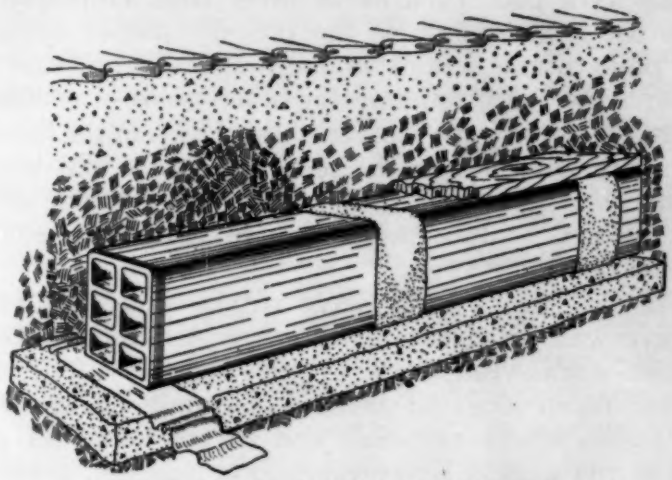


FIGURE 7—Method of Laying Multiple Duct.

This is somewhat like the "10 by 10" except that, instead of being divided into two rectangular compartments, a separate square hole is provided for each cable. Trouble was being experienced with the "10 by 10." While three cables could generally be placed on each shelf, a cable frequently could not be withdrawn as they settled together and became jammed; also the middle

shelf would break at a manhole and continue to break back into the conduit.

Our review, covering a period of more than ten years from the beginning of the business, has now brought us to a point where underground work is settling down to the use of the general types of construction that are best adapted to endure.

* * * * *

Returning to the present time, we find that vitrified clay ducts, in either the multiple or single form, have become the principal types of underground construction employed in the Bell System. Creosoted wood ducts have proved wholly satisfactory and their use has continued where initial cost, freight rates and other factors have been such as to favor their employment. Some use is also made at the present time of wrought iron pipes where serious underground obstructions are met and the space required for other types of construction is difficult or impossible to obtain. From the humble beginnings described in the preceding pages, the underground plant has grown until we now have, in the entire Bell System, a duct mileage more than sufficient to encircle the earth twice.

The last thirty years have witnessed a continuous improvement in every portion of the underground conduit work. Engineers of the General Staff have devoted much effort to devising economies in construction methods and materials and to perfecting all portions of the work. Every precaution has been taken to insure underground structures possessing permanence and stability, thus thoroughly safeguarding the investment in them.

FREDERICK L. RHODES

World's Telephone Statistics, 1922

DURING the year 1921, 1,083,409 telephones were added to the telephone systems of the world, an increase of 5.2%, bringing the total number of telephones in the world on January 1, 1922 to 21,948,960. Of this total, 13,875,183, or 63.2%, were in the United States, of which 13,380,219, or 96%, were connected to the Bell System. The number of telephones in all the countries of Europe combined was 5,606,252, or 25.5% of the world's total; all other countries had 2,467,525, or only 11.3% of the world's telephones. At the beginning of 1922, the total number of telephones in the world was equivalent to 1.3 for each 100 of the world's population, as against 1.2 at the beginning of 1921.

These figures are taken from a compilation of the world's telephone statistics for January 1, 1922 recently completed and published by the Chief Statistician's Division of the American Telephone and Telegraph Company. Similar figures for January 1, 1921, based upon a corresponding compilation for that date, were presented in an article in THE BELL TELEPHONE QUARTERLY for October, 1922. Through the continued kindly co-operation of officials of foreign telephone systems, re-enforced by the fact that conditions during the past year have been more nearly normal in many parts of the world, the present compilation is even more complete than its predecessor of a year ago. The accompanying tables and charts are taken from this compilation.

The table on "Telephone Development of the World, by Countries" shows that over one-half of the total net gain in telephones in the world during 1921 occurred in the United States; and this despite the fact that the extent of telephone service relative to population is very much greater in the United States than in any other country. In all Europe the gain in telephones during 1921 was only 342,085, as compared with 545,804 in the United States. On January 1, 1922, Europe still had

TELEPHONE DEVELOPMENT OF THE WORLD, BY COUNTRIES, JANUARY 1, 1922

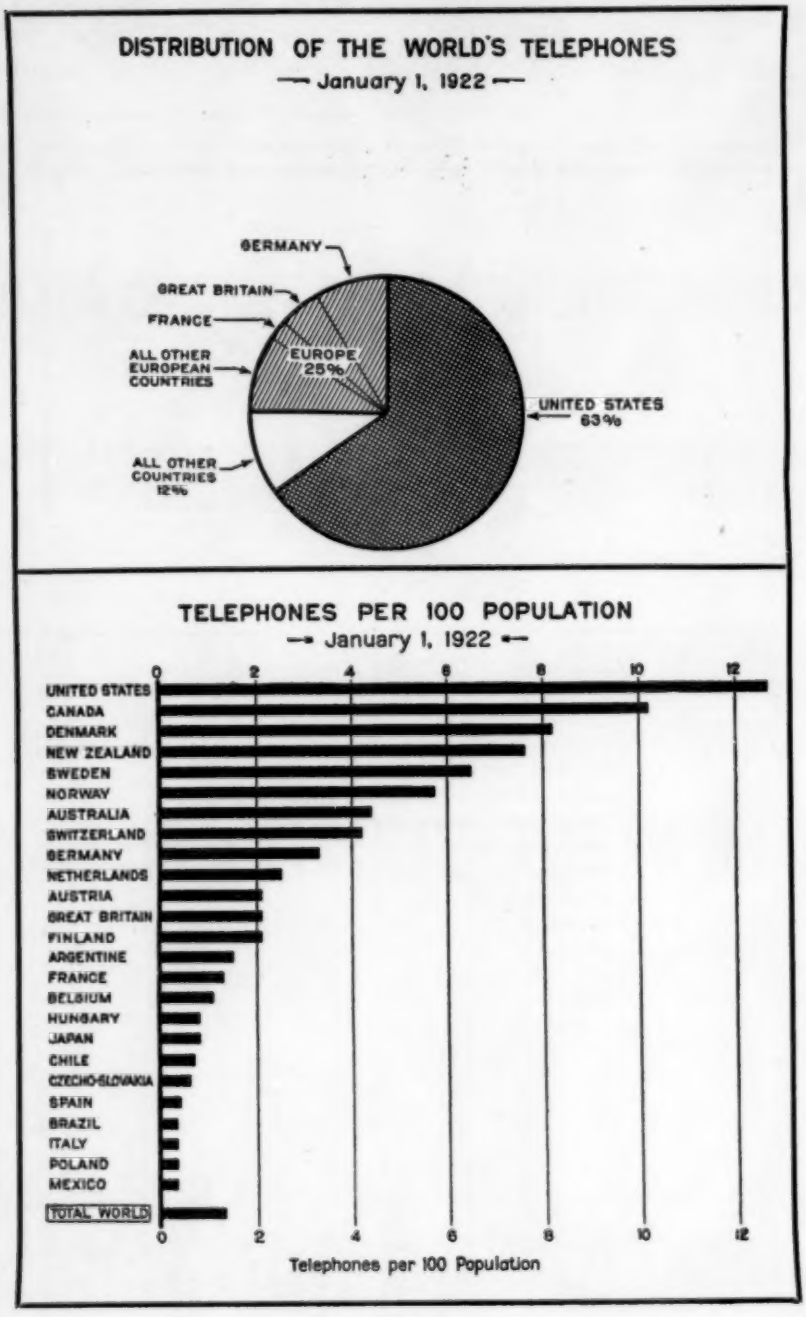
	Number of Telephones					
	Government Systems	Private Companies	Total	Per Cent of Total World	Telephones Per 100 Population	Increase in Number of Telephones during 1921†
NORTH AMERICA:						
United States	.....	13,875,183	13,875,183	63.22%	12.7	545,804
Canada	192,817	709,273	902,090	4.11%	10.2	45,824
Central America	6,672	9,905	16,577	.08%	0.3	627
Mexico	1,860	43,556	45,416	.21%	0.3	632
West Indies:						
Cuba	500	37,538	38,038	.17%	1.3	3,662
Porto Rico	560	8,542	9,102	.04%	0.7	1,132
Other W. I. Places*	3,388	7,512	10,900	.05%	0.2	762
Other No. Am. Places*	50	3,400	3,450	.02%	0.9	250
Total	205,847	14,694,909	14,900,756	67.90%	10.1	598,693
EUROPE:						
Austria	132,300	.....	132,300	.60%	2.1	‡
Belgium	80,509	.....	80,509	.37%	1.1	17,642
Bulgaria	6,600	.....	6,600	.03%	0.1	1,600
Czecho-Slovakia	81,953	.....	81,953	.37%	0.6	4,758
Denmark (March 31, 1922)	9,869	260,757	270,626	1.23%	8.2	18,305
Finland*	.....	70,000	70,000	.32%	2.1	‡
France	513,307	.....	513,307	2.34%	1.3	40,095
Germany	1,945,601	.....	1,945,601	8.86%	3.3	136,027
Great Britain and Ireland	997,805	.....	997,805	4.55%	2.1	11,841
Greece*	5,000	.....	5,000	.02%	0.1	300
Hungary	62,500	.....	62,500	.28%	0.8	5,491
Italy (June 30, 1921)	82,887	37,214	120,101	.55%	0.3	5,124
Jugo-Slavia	21,698	.....	21,698	.10%	0.2	5,259
Netherlands	175,027	997	176,024	.80%	2.5	14,091
Norway (June 30, 1921)	85,514	66,828	152,342	.69%	5.7	16,970
Poland	50,118	27,801	77,919	.35%	0.3	5,469
Portugal	1,890*	14,819	16,709	.08%	0.3	1,288
Roumania (March 31, 1922)*	28,000	.....	28,000	.13%	0.2	3,299
Russia	170,741	.....	170,741	.78%	0.1	‡
Spain*	9,600	72,900	82,500	.38%	0.4	12,500
Sweden	383,877	1,726	385,603	1.76%	6.5	—2,527¶
Switzerland	161,705	....	161,705	.74%	4.2	9,369
Other Places in Europe*	44,237	2,472	46,709	.21%	0.3	15,184
Total	5,050,738	555,514	5,606,252	25.54%	1.2	342,085

*Partly estimated. †Minus sign preceding a figure denotes decrease.
‡Accurate data not available, and basis for reliable estimate lacking. An arbitrary estimate, however, is included in total for Europe.
¶Decrease caused by consolidation of telephone plants in Stockholm.

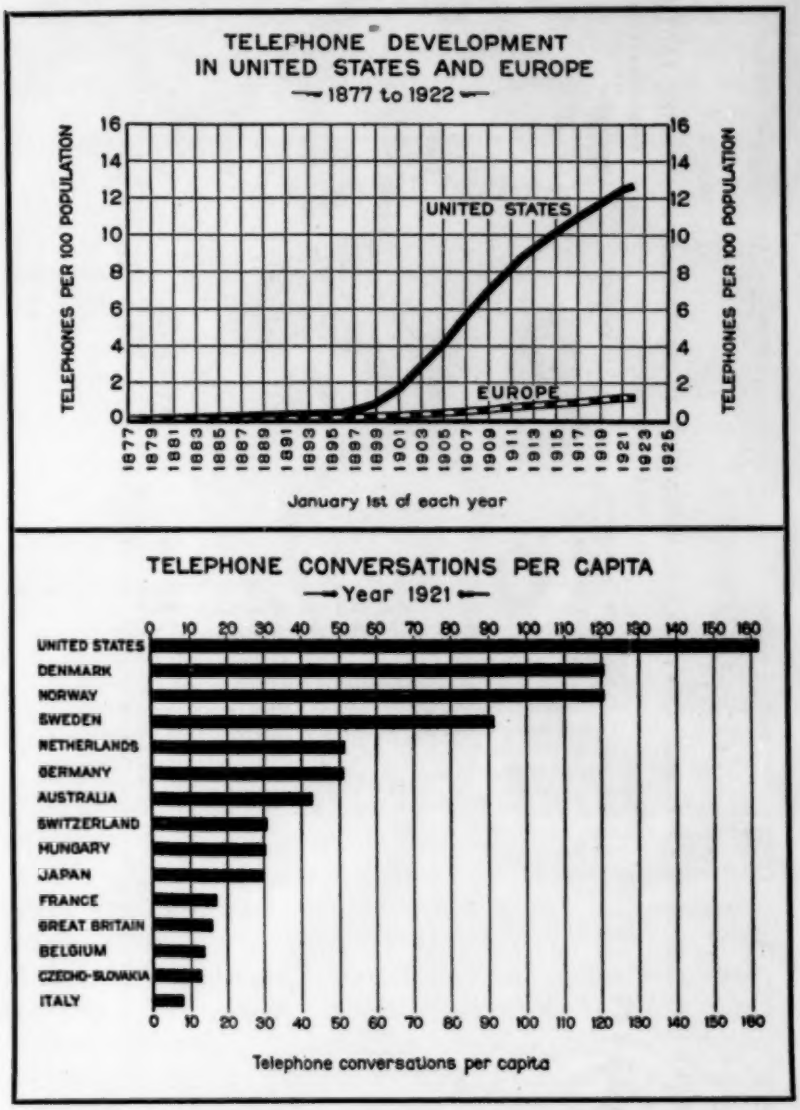
¶Decrease caused by consolidation of telephone plants in Stockholm.

	Number of Telephones			Per Cent of Total World	Telephones Per 100 Population	Increase in Number of Telephones during 1921†
	Government Systems	Private Companies	Total			
SOUTH AMERICA:						
Argentine	.....	130,727	130,727	.59%	1.5	14,174
Bolivia	.....	2,609	2,609	.01%	0.1	92
Brazil	1,247	86,339	87,586	.40%	0.3	2,495
Chile	.....	29,661	29,661	.13%	0.7	—206
Colombia	.....	7,301	7,301	.03%	0.1	458
Ecuador	1,425	2,611	4,036	.02%	0.2	90
Paraguay	86	320	406	.002%	0.04	0
Peru	2	8,619	8,621	.04%	0.2	69
Uruguay	.....	24,048	24,048	.11%	1.6	1,667
Venezuela	444	8,737	9,181	.04%	0.4	285
Other Places	2,133	.....	2,133	.01%	0.5	235
Total	5,337	300,972	306,309	1.38%	0.5	19,359
ASIA:						
British India (March 31, 1922)	12,399	23,958	36,357	.17%	0.01	2,089
China*	59,390	24,046	83,436	.38%	0.03	8,976
Japan	425,037	.....	425,037	1.94%	0.8	54,000*
Other Places in Asia*	54,585	5,844	60,429	.27%	0.05	6,109
Total	551,411	53,848	605,259	2.76%	0.1	71,174
AFRICA:						
Egypt	25,185	.....	25,185	.11%	0.2	2,905
Union of South Africa§	56,081	.....	56,081	.26%	0.8	4,679
Other Places in Africa*	44,933	1,130	46,063	.21%	0.04	17,539
Total	126,199	1,130	127,329	.58%	0.1	25,123
OCEANIA:						
Australia (June 30, 1921)	240,507	.....	240,507	1.10%	4.4	16,507
Dutch East Indies	34,936	1,905	36,841	.17%	0.1	2,337
Hawaii	.....	15,124	15,124	.07%	5.6	748
New Zealand (March 31, 1922)	94,683	.....	94,683	.43%	7.6	6,244
Philippine Islands*	2,110	11,420	13,530	.06%	0.1	1,079
Other Places in Oceania*	2,000	370	2,370	.01%	0.1	60
Total	374,236	28,819	403.055	1.84%	0.6	26,975
TOTAL WORLD	6,313,768	15,635,192	21,948,960	100.00%	1.3	1,083,409

*Partly estimated. †Minus sign preceding a figure denotes decrease §March 31, 1922.


DISTRIBUTION OF THE WORLD'S TELEPHONES
January 1, 1922
GERMANY
GREAT BRITAIN
FRANCE
ALL OTHER EUROPEAN COUNTRIES
EUROPE 25%
UNITED STATES 63%
ALL OTHER COUNTRIES 12%
TELEPHONES PER 100 POPULATION
January 1, 1922
0
2
4
6
8
10
12
UNITED STATES
CANADA
DENMARK
NEW ZEALAND
SWEDEN
NORWAY
AUSTRALIA
SWITZERLAND
GERMANY
NETHERLANDS
AUSTRIA
GREAT BRITAIN
FINLAND
ARGENTINE
FRANCE
BELGIUM
HUNGARY
JAPAN
CHILE
CZECHO-SLOVAKIA
SPAIN
BRAZIL
ITALY
POLAND
MEXICO
TOTAL WORLD
Telephones per 100 Population

but 1.2 telephones per 100 population, as against 12.7 in the United States on the same date. The relative



number of telephones in Europe today is no greater than that which existed in the United States in 1900.

TELEPHONE DEVELOPMENT OF LARGE AND SMALL COMMUNITIES IN IMPORTANT COUNTRIES, JANUARY 1, 1922

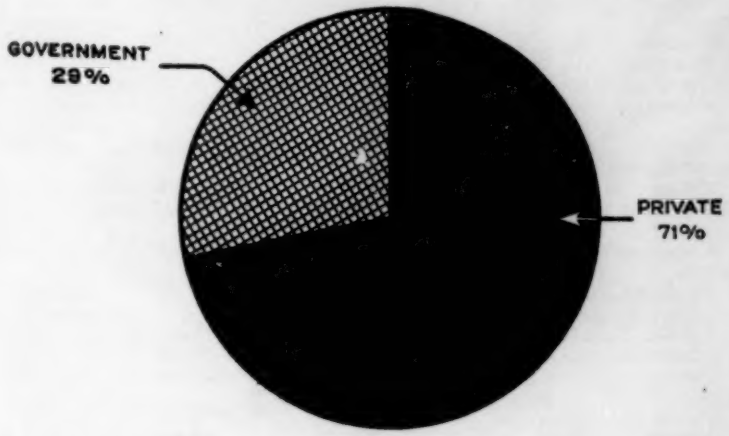
Country	Service Operated by (See Note)	Number of Telephones		Telephones per 100 Population	
		In Communities of 100,000 Population and over	In Communities of less than 100,000 Population	In Communities of 100,000 Population and over	In Communities of less than 100,000 Population
Australia	G.	152,288	97,204*	6.4	3.1
Austria	G.	94,800	37,500	4.7	0.8
Belgium	G.	54,010	26,499	2.5	0.5
Canada	P. G.	318,599	583,491	15.2	8.6
Czecho-Slovakia	G.	26,626	55,327	3.0	0.4
Denmark	P. G.	106,105	159,946*	14.8	6.2
France	G.	251,316	261,991	4.1	0.8
Germany	G.	1,039,778	905,823*	6.9	2.1
Great Britain and Ireland	G.	752,446	260,308	3.2	1.1
Hungary	G.	44,161	18,339	3.9	0.3
Japan	G.	256,058	168,979	3.5	0.3
Netherlands	G.	88,660	87,364	5.2	1.7
New Zealand (March 31, 1922)	G.	30,348	64,335	8.0	7.4
Norway (June 30, 1921)	P. G.	30,356	121,986	11.8	5.0
Russia	G.	102,441	68,300	3.4	0.1
Sweden	G.	144,942	240,661	20.8†	4.6
Switzerland	G.	57,566	104,139	9.9	3.1
United States	P.	5,725,902	8,149,281	16.5	11.0

NOTE: P. indicates telephone service operated by private companies, G. by the Government, and P. G. by both private companies and the Government.
†The majority of this development is due to Stockholm. See note on Stockholm in table of Telephone Development of Important Cities.
*Partly estimated

Among the individual European countries, the relative extent of telephone facilities continues to be the greatest in Denmark, where the service is conducted almost wholly by private companies. The number of telephones per 100 population (8.2) in Denmark is, as a matter of fact, exceeded only by that in the United States and

OWNERSHIP OF THE WORLD'S TELEPHONES

— January 1, 1922 —



Canada of all the countries in the world. It is interesting to note that during 1921 Germany showed a net gain of 136,027 telephones, as compared with a gain of 40,095 in France and only 11,841 in Great Britain. At the beginning of 1922, Germany had 3.3 telephones per 100 population, as compared with 2.1 in Great Britain and 1.3 in France. The predominance of the United States in telephone communication is indicated by the fact that, relative to population, this country has about four times as many telephones as Germany, about six times as many as Great Britain, and about ten times as many as France. Another interesting fact shown by this table is that Russia, on the basis of the first official figures received since before the war, had only 0.1 telephone per 100 population. Moreover, the total of 170,741 telephones in Russia is

TELEPHONE DEVELOPMENT OF IMPORTANT CITIES, JANUARY 1, 1922

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
ARGENTINE:			
Buenos Aires	1,700,000	73,828	4.3
AUSTRALIA:			
Adelaide	261,000	17,022	6.5
Brisbane	218,000	13,202	6.1
Melbourne	795,000	50,777	6.4
Sydney	926,000	62,295	6.7
AUSTRIA:			
Gratz	158,000	4,800	3.0
Vienna	1,842,000	90,000	4.9
BELGIUM:			
Antwerp	469,000	12,565	2.7
Brussels	861,000	28,760	3.3
Charleroi	206,000	2,698	1.3
Ghent	279,000	3,740	1.3
Liège	300,000	6,247	2.1
CANADA:			
Montreal	840,000	83,917	10.0
Ottawa	159,000	24,996	15.7
Toronto	570,000	101,452	17.8
CHINA:			
Canton	900,000	2,475	0.3
Shanghai	1,500,000	16,466	1.1
Tientsin	800,000	6,631	0.8
Peking	1,300,000	30,000‡	2.3
CUBA:			
Havana	456,000	27,318	6.0
CZECHO-SLOVAKIA:			
Prague	677,000	20,008	3.0
DANZIG, FREE CITY OF	357,000	12,957	3.6
DENMARK:			
Copenhagen	717,000	106,105	14.8
FRANCE:			
Bordeaux	267,000	8,285	3.1
Lille	201,000	5,281	2.6
Lyons	562,000	11,891	2.1
Marseilles	586,000	12,444	2.1
Paris	2,906,000	173,300	6.0
GERMANY:			
Berlin	3,804,000	347,735	9.1
Bremen	270,000	19,684	7.3
Breslau	528,000	27,736	5.3
Chemnitz	304,000	15,051	5.0
Cologne	634,000	38,666	6.1
Dresden	588,000	36,218	6.2
Düsseldorf	407,000	26,288	6.5
Essen	439,000	15,717	3.6
Frankfort-on-Main	433,000	37,705	8.7
Hamburg-Altona	1,155,000	95,534	8.3
Hannover	393,000	23,102	5.9
Leipzig	604,000	41,906	6.9
Magdeburg	286,000	14,654	5.1
Munich	631,000	46,214	7.3
Nuremburg	353,000	23,671	6.7
Stuttgart	309,000	26,211	8.5
GREAT BRITAIN AND IRELAND:*			
Belfast	414,000	9,168	2.2
Birmingham	1,286,000	27,615	2.1
Blackburn	252,000	4,972	2.0
Bolton	282,000	4,684	1.7
Bradford	379,000	12,118	3.2
Bristol	409,000	10,202	2.5
Dublin	391,000	11,294	2.9
Edinburgh	424,000	16,670	3.9
Glasgow	1,273,000	42,655	3.4
Hull	328,000	13,570	4.1
Leeds	541,000	13,287	2.5
Liverpool	1,202,000	38,895	3.2
London	7,139,000	341,498	4.8
Manchester	1,607,000	48,274	3.0
Newcastle	603,000	13,620	2.3
Nottingham	337,000	9,281	2.8
Plymouth	232,000	3,852	1.7
Sheffield	510,000	11,939	2.3

* Statistics as of March 31, 1922.
‡ Partly estimated.

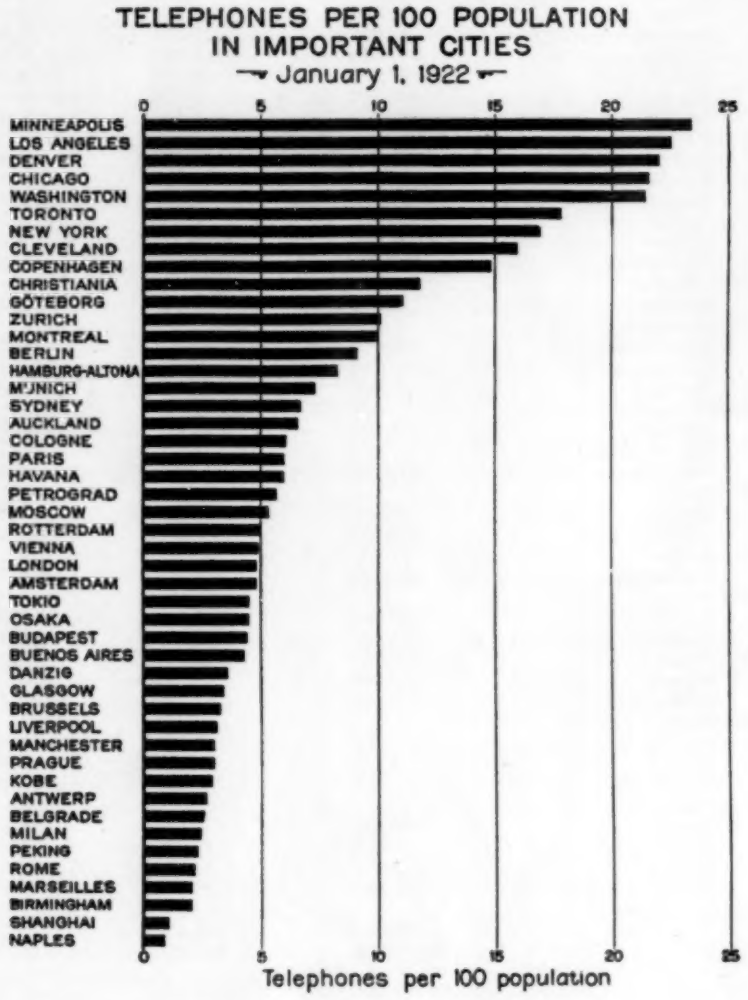
TELEPHONE DEVELOPMENT OF IMPORTANT CITIES, JANUARY 1, 1922

(Concluded)

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
HUNGARY:			
Budapest	926,000	40,993	4.4
Szegedin	110,000	2,023	1.8
ITALY:†			
Florence	247,000	4,667	1.9
Genoa	299,000	7,999	2.7
Milan	701,000	16,944	2.4
Naples	770,000	6,344	0.8
Palermo	400,000	2,342	0.6
Rome	637,000	14,025	2.2
Turin	500,000	7,438	1.5
Venice	165,000	2,451	1.5
JAPAN:			
Kobe	637,000	18,725	2.9
Kyoto	613,000	17,786	2.9
Nagoya	617,000	15,008	2.4
Osaka	1,296,000	58,590	4.5
Tokio	2,304,000	103,524	4.5
Yokohama	431,000	12,380	2.9
JUGO-SLAVIA:			
Belgrade	112,000	2,937	2.6
NETHERLANDS:			
Amsterdam	689,000	32,931	4.8
The Hague	362,000	24,306	6.7
Rotterdam	524,000	26,057	5.0
NEW ZEALAND:*			
Auckland	161,000	10,678	6.6
Christchurch	107,000	8,265	7.7
Wellington	109,000	11,405	10.4
NORWAY:†			
Bergen	95,000	8,450	8.9
Christiania	258,000	30,356	11.8
ROUMANIA:			
Bucharest	350,000	8,600‡	2.5
RUSSIA:			
Kazan	246,000	1,126	0.5
Kharkov	474,000	5,008	1.1
Moscow	1,028,000	54,707	5.3
Odessa	565,000	1,600	0.3
Petrograd	706,000	40,000	5.7
SWEDEN:			
Göteborg	205,000	22,804	11.1
Malmö	114,000	12,043	10.6
Stockholm	377,000	110,095°	29.2°
SWITZERLAND			
Basel	136,000	12,179	9.0
Berne	105,000	10,205	9.8
Geneva	135,000	14,199	10.5
Zurich	207,000	20,983	10.1
UNITED STATES:			
New York	5,796,000	979,534	16.9
Chicago	2,808,000	605,495	21.6
Total of the 5 cities with over 1,000,000 population	13,170,000	2,317,830	17.6
Cleveland	966,000	153,951	15.9
Los Angeles	722,000	162,118	22.5
Total of the 12 cities with 500,000-1,000,000 population	8,239,000	1,322,036	16.0
Washington	449,000	96,111	21.4
Minneapolis	411,000	96,166	23.4
Denver	267,000	58,751	22.0
Total of the 16 cities with 250,000-500,000 population	5,105,000	928,175	18.2
Total of the 33 cities with over 250,000 population	26,514,000	4,568,041	17.2

* Statistics as of March 31, 1922. † Statistics as of June 30, 1921. ‡ Partly estimated

° The greater part of this development was secured by a private Company which was purchased by the Government in 1918. On January 1, 1922, the process of merging the private Company's plant with the Government's local system was not fully completed. Therefore the total number of telephones includes a certain number of duplicates.



NOTE—This chart shows the comparative telephone development of the largest cities in the countries listed on the preceding pages. In the case of Sweden, however, the city of Göteborg is shown instead of the largest city, Stockholm, since the total number of telephones in Stockholm includes a certain number of duplicates with the result that its telephone development is not fully significant. Stockholm is, however, undoubtedly among the best developed cities in the world from a telephone standpoint. The United States cities shown include, in addition to New York and Chicago, a number of representative cities having a population between 250,000 and 1,000,000.

less than the number in that country at the close of 1913. Even allowing for the reduction in the number of telephones resulting from loss of territory during the intervening years, there appears to have been no increase of consequence in Russia's telephone development.

The table on "Telephone Development of Large and Small Communities in Important Countries" indicates that the distribution of telephone facilities with respect to the size of communities is much more even in the United States than in any European country. It is generally noted in all foreign countries that the bulk of the telephone development is to be found in the larger communities, while less populous communities and especially rural districts are comparatively neglected. Notwithstanding this condition, however, the table on "Telephone Development of Important Cities" shows that in the matter of telephone service foreign cities are relatively little developed as compared with American standards. Outside the United States and Canada, it is exceptional for a city to have as many as 10 telephones per 100 population; in Great Britain, for example, no city had as many as 5 telephones per 100 population on January 1, 1922. On the other hand, the 33 cities in the United States which had a population of 250,000 or over on January 1, 1922 showed an average of 17.2 telephones for every 100 inhabitants. In point of absolute number of telephones, large cities in the United States not only have more telephones than foreign cities of comparable size, but even have more telephones than the whole of most foreign countries. For example, reference to this table and to the table on "Telephone Development of the World, by Countries" indicates that Chicago has more telephones than all of France and that Cleveland has more than all of Italy. On January 1, 1922, New York City had nearly as many telephones as Great Britain and Ireland, and today has more.

S. L. ANDREW.

Two Founders of the Bell System

Intimate impressions of Thomas Sanders and Gardiner Greene Hubbard gathered from historical and personal sources.

THOMAS SANDERS was standing in the large hall of "Birchbrow," his beautiful residence on the edge of Haverhill, Massachusetts, one early spring afternoon, looking at the fire in the great open fireplace and meditatively smoking a cigar. A striking figure, erect, and a handsome man. With any one his keen black eyes first commanded attention, moving quickly here and there above his spreading black full beard. He always wore good clothes, and he wore them well.

One of his boys was looking out of the drawing room window down the hill toward the lake, around the shore of which the driveway swept up to the house. "What is that?" the youngster called out. "What is it?" his father asked without moving or stopping smoking. "A team with a lot of men. And another." Mr. Sanders went leisurely into the drawing room and over to the window. Around the curve of the hill down by the lake came one by one a string of wagons, four of them, every one of them loaded with men. There were something like sixty-five men in all, and all of them in red. "There's Uncle Charlie, hanging on to the last one!" exclaimed the boy. The two went out onto the verandah and stood at the top of the broad flight of steps that led up to the front door, waiting to see what it was, who they were, coming in red uniforms, with his brother bringing up the rear of the procession like the conductor of a line of busses.

As the last wagon drove up to the house and stopped, Charles Sanders sang out, "Here they are, Tom! I've come to pay my bet." A loud, hearty, delighted laugh was Mr. Sanders' reply, as in a flash he remembered the bet and understood the whole affair. A long time before

he had tried to get his brother to take some stock in the telephone company. But Charles Sanders had grave doubts of the future of the enterprise; it was altogether too risky. In fact all the rest of the family succumbed to Thomas Sanders' persuasions before he did. So as a final argument Thomas Sanders had come back at his brother with what was to them the supreme challenge,"If that stock does not go over par, I will hire the whole Salem Cadet Band, bring them to your place, and give you the finest band concert you ever heard in your life!" The two brothers were as crazy over bands as two small boys, and would often drive far out of their way to follow a good band in the street. And the Salem Cadet Band! Even the Boston Cadets would freely acknowledge that the Salem Cadet Band was the best in all the region north of Boston. "And if it does," Charles took his brother up, "I will bring them to Haverhill and give you a concert. And I will buy the stock to boot!"

In due time the stock went up over par. No burden of obligation weighed upon his mind, so Thomas Sanders forgot all about the concert due him. But Charles had not forgotten. It was a great concert that was given up there on the hill out under the trees. Thomas Sanders telephoned for a lot of friends, and sent carriages and teams and the busses for a good many of them. Everyone had a jolly time. After the first number, Thomas Sanders called for a favorite tune, and then Charles called for one; and so on. They kept it up far into the evening. The players might have been exhausted, but the story goes that they were not. Thomas Sanders supplied refreshments, and plenty of them. He was a generous man. The opening to his pocket was large. And this was in the early days.

This was the man who financed the early experiments that led up to the invention of the telephone. A leather merchant and man of means, he put in $110,000, a large sum in those days, before he got back a cent of it. The story comes from a close friend of Mr. Sanders and from

a son, the boy who was looking out of the window. It is entirely characteristic of the man. But though genial and gay of spirit, Mr. Sanders knew trouble, and it was through trouble that Thomas Sanders came in contact with Alexander Graham Bell.

First Meeting of Sanders and Bell

Thomas Sanders' oldest child was born deaf. It seemed certain that the little fellow must go through life isolated. The sign language for the deaf made communications possible, but only to a limited extent, for the deaf could thereby converse only with those who knew the language—that is, other deaf persons, teachers of the deaf, and a few others. Usually even from their own families the deaf were practically isolated. It was a lonely life. The little Sanders boy had grown to be four or five years old; his education ought to be beginning.

About this time Mr. Sanders heard that Boston had in its public school system a day school specially for deaf children, where lip-reading was taught. By this method the deaf could "hear" by watching the lips of anyone speaking to them and in turn could learn to speak intelligibly. This method was taught but little in America. The teachers of the deaf most of them considered it waste of time. The chief advocate of the lip-reading method was a Mr. Hubbard, who lived in Cambridge, a lawyer and member of the Massachusetts State Board of Education. Further, there was at this school for the deaf a young teacher, about 27 years old, who had a special way of teaching lip-reading which was of very great advantage; the pupil learned faster and the results were much better. He called his method "Visible Speech"; it had been invented by his father. The young teacher's name was Bell.

It was not long before Mr. Sanders had looked into the whole matter. He met Mr. Bell, a tall young man, devoted to his pupils and to his work for them. His face was one not easy to forget. His complexion was very

pale, contrasting strongly with his black wavy hair, moustache and side whiskers, and unusually dark eyes, whose expression was quiet and dreamy but sometimes piercing and enthusiastic. After careful consideration Mr. Sanders decided that this young man was the one to teach his boy. Never doing anything half-way, he arranged for Mr. Bell to take little George as a private pupil in Boston. Then as it was not practicable for the child to live in Boston, and as it was not practicable for Mr. Bell to come to Haverhill, it was arranged that from October 1, 1873 on, the child was to live in Salem with his grandmother, Thomas Sanders' mother, and that Mr. Bell was to live there too, going to Boston whenever necessary for his classes in town. Mr. Sanders also found that Mr. Bell had a secondary interest, a hobby, of experimenting with electrical apparatus, that he was indeed something of an inventor, or hoped to be. So it was further arranged that he should have the attic of the Sanders house in Salem for his workshop, to experiment in.

The private tutoring was a great success. Bell did wonders for the boy. Mr. Sanders could not sufficiently express his gratitude. He sought for some way to show his appreciation. There was Bell's electrical experimenting. Unavoidably it ate up money. But it might lead to something after all. Mr. Bell, like many others, Elisha Gray included, thought he could invent a way of sending more than one message over a single telegraph wire at the same time. If he could, there would surely be money in it; the Western Union Telegraph Company would buy it up at once. Young Bell talked convincingly; and what he had actually accomplished seemed to be on the right track. Then too he had some ideas about a device for talking over a telegraph wire. Mr. Sanders did not see so much in that, but if Bell could make a success of it, it would be interesting at least. However, whether Bell's experimenting led to profitable results or not, Mr. Sanders felt deeply grateful, if not indebted, to him; and he liked Bell. Bell would certainly need a

good deal of money to complete his experiments, to take out his patents and to negotiate an advantageous sale of his inventions, as much as $2,000 or $3,000, and possibly it might run up to as much as $5,000. But where could that young teacher of the deaf get so much money? He made up his mind what he would do. Then, too, who could tell, there might be money in Bell's ideas!

So in the fall of 1874 Thomas Sanders had a talk with Alexander Graham Bell and voluntarily made him an offer to supply him with whatever money he might need for his experiments, making payments from time to time on bills rendered, in return for a one-half interest in any inventions that might result.

Curiously enough, a few days later Gardiner G. Hubbard made a similar offer to Mr. Bell. Naturally Mr. Bell talked the whole matter over with both of his friends, and it was finally agreed that the three should form a partnership, in which Mr. Sanders and Mr. Hubbard should each undertake to supply half of what money should be needed in return for a third interest each in the resultant patents, if there were any.

It would be more correct to say that Mr. Hubbard came into contact with Alexander Graham Bell through his public spirit than through any misfortune, though in the main the story reads remarkably like that of Mr. Sanders. In the winter of 1861-1862 a severe attack of scarlet fever left Mr. Hubbard's little four year old daughter totally deaf. Following the advice of their friend, Dr. Samuel G. Howe, the parents turned away from the prevailing method of the sign language for the education of their little girl and started in to bring the child up in accordance with the principles of lip-reading. And in this they were notably successful.

Hubbard's Interest in the Deaf

Mr. Hubbard was instinctively a public spirited man. Even his own personal troubles he was habitually apt to think over in terms of the public welfare. When he

found that lip-reading was doing so much for his little Mabel, he accordingly began to consider what could be done to introduce the system widely into the education for the deaf in America.

He was a man of successful experience in advancing matters of civic improvement. Already in 1853 through his efforts and leadership illuminating gas had been introduced into Cambridge and the streets lighted. In 1855, chiefly through him, the Cambridge Water Works was organized and the town was given a reliable supply of pure water. In 1856 the first street railway, except in New York City, was opened as a result of his work between Cambridge and Boston. So again in 1864 he started a campaign to secure from the Massachusetts Legislature a charter for an institution for the education of the deaf where the lip-reading method should be introduced and with it an appropriation of $5,000 a year toward its support. Finally, in 1867 the charter was secured and the Clarke Institution for Deaf-Mutes at Northampton was organized. In 1869, through the efforts of Mr. Hubbard and of the Rev. Dexter S. King, a member of the Boston School Board, a day school for the deaf, later called the Horace Mann School, was started in the Boston public school system, with Miss Sarah Fuller in charge as principal. So Mr. Hubbard had been actively working for the deaf for at least seven years before Mr. Bell came to Boston.

In the fall of 1868, Professor Alexander Melville Bell, Alexander Graham Bell's father, gave a series of lectures in the courses of the Lowell Institute at Boston. In these lectures Professor Bell spoke of what had been done for deaf children by means of his Visible Speech in London. Miss Fuller was present at these lectures. In 1870 Professor Bell lectured under the Lowell Institute again. Miss Fuller had now become principal of the school for the deaf, so as Professor Bell was to be in Boston for six weeks, she asked him if he could not come to her school and instruct her teachers in the use of Visible Speech in

the education of the deaf. His engagements prevented his doing this, but he said that his son, Graham, could doubtless come to Boston, and that as it was Graham who had introduced Visible Speech into the school for the deaf children in London, he could do the same in Boston. Miss Fuller then immediately went to Mr. Hubbard and Mr. King. They at once took hold of the matter energetically and in consequence in April 1871, Alexander Graham Bell took up his duties in the Boston School for the Deaf at 11 Pemberton Square, and started in on his life career as one of the greatest teachers and friends of the deaf in America. It was in this way that Gardiner Greene Hubbard came to know Alexander Graham Bell. The two at once became closely associated with each other in this work.

Meantime little Mabel Hubbard had made wonderful progress in lip-reading. By the time she was nine years old she could speak freely and was in every way the equal in education of children of her own age who could hear. In May, 1870, she was taken abroad, to Germany, the headquarters of the lip-reading school of education, and continued to progress until she was markedly proficient. She did not return to America until the fall of 1874.

Formation of "Bell Patent Association"

By the fall of 1874 Gardiner Greene Hubbard had known the young teacher for more than three years. Bell had been in the habit of going to the Hubbard house in Cambridge frequently. Mr. Hubbard knew all of Bell's interests. He knew about his electrical experimenting. He perceived promise of very practical commercial value in Bell's ideas for sending two or more messages over a single telegraph wire at the same time. Since 1867 Mr. Hubbard had been giving much time and attention to the study of the postal and the telegraph systems and to urging many practical improvements in those services. Accordingly he was specially interested

in Bell's ideas for a multiple telegraph and specially competent to form an opinion of their value. He thought the matter over very carefully and then made to Bell of his own accord an offer to undertake to supply the money necessary for his electrical experiments if Bell would give him in return a one-half interest in his inventions. He learned that the father of one of Bell's private pupils, Mr. Thomas Sanders of Haverhill, had a short time before made him practicaily the same proposition. So the three got together and formed an informal partnership, as before stated. About four months later, when Bell's first harmonic telegraph invention was ready for submission to the Patent Office, an agreement was drawn up between them, dated February 27, 1875, putting the understanding in writing. This has elsewhere been called the "Bell Patent Association."*

Hardly could two men have been more unlike than Gardiner Hubbard and Thomas Sanders. Mr. Sanders was a regular business man, well-known to be conservative in his attitude toward financial matters, but a lavish friend and a free spender. His striking personality expressed itself in his clothes. They always had an air of cheery sensation about them without being quite sensational. One suit was a small black and white check, with which he wore a flaming orange tie of plain silk. Indeed one clothing store in Haverhill used to save out any suit or overcoat that was too striking to sell easily and the proprietor would say, "Oh, lay that aside; I will sell it to Tom Sanders." and as a matter of fact Mr. Sanders usually did buy it sooner or later. Mr. Sanders enjoyed his clothes thoroughly.

Contrasted Personalities of Sanders and Hubbard

Mr. Hubbard was a lawyer, shrewd and cautious, yet far-sighted and perhaps somewhat visionary. At heart he was a civic promotor utterly intent upon the causes

*See *Bell Telephone Quarterly*, July, 1923. W. C. Langdon: The Early Corporate Development of the Telephone, on pages 134–135.

on which he had set his mind. Some called him close in money matters, though at the same time declaring him a most lovable man. But he was not at this time at all a man of means. He paid no attention to his clothes. They were comfortable; at least he was. Nor did any one else pay any attention to them. Probably the reputed "closeness" was the result of his indifference to money compared to the end he had in mind. This often put him into tight corners and made him count the pennies one by one between times scrupulously.

For example, in 1877 he considered it important for him and Mr. Watson to go to Altoona, Pennsylvania, to install an experimental telephone line for the Pennsylvania Railroad. Money was scarce. But to get there and to make the installation was the only thing that counted in Mr. Hubbard's mind. So he went and took Mr. Watson with him. It has been said, however, that he had to borrow from someone in Altoona the money to get back to Philadelphia, and from Mr. Thomas E. Cornish the money to get back to Boston. Nonetheless he had accomplished the important thing. Any inconvenience to himself, or to others, was a negligible matter.

Working in this spirit, seeing far ahead with the eye of his imagination and keen judgment in public affairs, it is easy to understand how he set himself in the 50's to bring about the needed improvements in his city, quite irrespective of the personal question of whether he could afford to give the time from his profession or not. Visionary? Yes, but also most practical—for the benefit of others, though not for himself. One great thing he knew and went boldly ahead on the knowledge of it,—that imagination is more often lacking than money; supply the imagination and the necessary money is easily found.

So life must have seemed to Gardiner Greene Hubbard an unresting scrutiny of the horizon for civic possibilities, sighting an object afar off, and step by step with untiring shrewdness, miserly of his attention to other things or even to his own other interests, regardless of other people's

opinions or convenience, working toward his object, stalking it, weaving a net around it, until he had it secured for the community.

For Thomas Sanders life passed from one exhilarating moment to another with longer or briefer intervals between the high points. To feel the whole ecstatic thrill of life, summed up in one intense joyful instant, that was the thing! A friend of his said that Thomas Sanders was very fond of horses, but after all, he thought, probably more for the sake of the races than for the sake of the horses. To see the winning horse come in across the line, neck outstretched, staring eyes, open nostrils, bandaged hoofs in a rapid rat-tat-tat pounding the track, a beautiful piece of horse-flesh in perfect form flashing across the line, with the second just behind,—that was a moment of pure complete life itself! To lead up to that,—what work, money, endless training, patient waiting,—what was not worth while!

So too in more serious, more important things, failure and loss with Thomas Sanders were quickly forgotten. To attain, to win out, and the joy of it, was the only thing that occupied his mind, before or after. To illustrate: Leather, the telephone, and silver were the chief financial interests of his life. One time a complaint was made of him that he had lost three great fortunes. It came to his ears. His comment to his wife was simply that it might be true, but what of it? it was not every fool that could make three great fortunes to lose.

Sanders' Unwavering Loyalty to Bell

So in personal affairs and friendship. Thomas Sanders had given the young tutor to understand that he would financially stand back of his electrical experiments. True, he had undertaken to meet only half of the expenses, but Mr. Hubbard had proved unable to make good his half, and his original offer had been to take care of the whole. True, the amount was running far beyond any figure of which he had ever dreamed: $5,000 had been

but a drop in the bucket; $10,000 was gone; $25,000; $50,000 was disappearing. Mr. Sanders put in not only all his available cash, but mortgaged his property and staked his credit. He lost his reputation as a safe and conservative investor. One day his banker met him on the street and asked him to oblige him by taking his telephone paper out of the bank, as the inspector was coming the next day and he did not like to be caught with it on his hands. But all this made no difference to Mr. Sanders, so far as any one could see. For with Thomas Sanders, once a friend, always a friend. He would see it through, whatever happened. And he did believe in it—the telephone. He would bet on it; he had, heavily! He may have worried, but if so, the only way he showed it was with a laugh. So it was that he sank $110,000 in the telephone, for the experiments, for securing the patents, and for starting the business—twice as much as his promise had required, and twenty times as much as he had originally thought of doing,—before he got a dollar back.

But if Mr. Hubbard was not able to put in his half of the money for the financing of the telephone, he did quite as much in his own way and true to his own character The early development of the telephone was not a mere matter of routine daily duties. There was much human friction, as must needs be with such genuine individualities as the group of men who had gathered together for its service. Deliciously characteristic was a little contre-temps between Mr. Hubbard and Mr. Sanders at the time when Mr. Hubbard as Trustee of the Bell Telephone Company had the entire control in his hands and when Mr. Sanders was Treasurer. Mr. Sanders once went so far, under special provocation, as to complain to Mr. Hubbard of the serene way he went ahead incurring obligations when the treasury was empty and he could only with great difficulty find money for the pay-roll. Mr. Hubbard came back with a rebuke to Mr. Sanders for blindness of vision that he could not see the glorious

future of the telephone and added that it was the part of the treasurer to find the money, not to get discouraged. And Mr. Hubbard was right, judged from his own standpoint. They were both right, each in his own position. But their positions were different!

It was by the same arbitrary wisdom that Mr. Hubbard took matters into his own hands and directed Anthony Pollok, the patent attorney, to go ahead and file the application for the first telephone patent without saying anything about it to Mr. Bell. This saved the patent, it may be, by just two hours. So also it was entirely to Mr. Hubbard's credit, as Dr. Bell himself said, that the telephone was exhibited at the Centennial in Philadelphia in 1876, and at that exceptionally advantageous time introduced to the scientific world in the persons of Joseph Henry, Sir William Thomson, and the eminent amateur scientist, Dom Pedro, Emperor of Brazil.

It has been said that Mr. Hubbard did not at first appreciate Alexander Graham Bell. This is far from true. Mr. Hubbard was too shrewd and far-seeing in his knowledge of men not to recognize and accurately appraise the value of the young man who for five years was continually thrown with him in work for the welfare of the deaf. He appreciated young Bell as a true-gauged, human-hearted soul; he appreciated him no less as an inventive genius. He also appreciated him as one who was quite innocent of any ability for business or liking for the same. When Miss Mabel Hubbard at the age of seventeen returned to America, Mr. Bell met her at her father's house and the young people saw much of each other in the family circle. While she may have taken a few lessons from Mr. Bell, in order to get acquainted with the principles of Visible Speech, Miss Hubbard cannot correctly be said to have been a pupil of his. But Mr. Bell was always welcome at the house, as before, and the acquaintance grew into friendship and love.

When the question of the young people marrying

came up, however, Mr. Hubbard was first of all a father. His love and solicitude for his daughter brought all his native caution to the front. His attitude was not the less appreciative of the fine young suitor, in that he recognized that as a provider for a wife and children Bell's absolute lack of business ability had become the most serious fact in the situation. It was for this right and most natural reason that he earnestly encouraged, and maybe suggested, the idea that at their marriage Bell should make over to his bride practically all his telephone interests, with himself, Mr. Hubbard, as her guardian. It was wise for both their sakes, and by this arrangement Dr. Bell was all his life relieved from this kind of responsibility and his mind freed for other things.

Beginning of Policy of Selling Service and Not Instruments

The greatest thing that Gardiner Greene Hubbard did in his administration of the telephone was establishing the business policy of the telephone on the principle of renting telephones and not selling them. As attorney for the Gordon MacKay Shoe Machinery Company he saw that principle in practice. He realized that it was the wisest principle on which to build up the telephone business. As he was Trustee he was able to adopt it without gaining first the consent of anyone, and he held to it persistently against both the severe pressure of lack of money and the united opposition of all the others concerned. Even Mrs. Hubbard, his own wife, at one time went to Mr. Watson in the shop to beg him to join them and to add what influence he might have with Mr. Hubbard to persuade him to sell telephones instead of renting them, so much more money would be received in that way and they needed money so badly. But Mr. Hubbard stood firm. He had the power and nothing could move him from the policy. And the whole business structure of the Bell System is built upon his position; if he had yielded, it could not have been. The

renting of telephones led to the licensing system, and the licensing system led to the sale of service only. This indifference to money, so characteristic of him, was the concomitant of his far-sighted wisdom and his determination to bring the right thing about.

Thomas Sanders and Gardiner Greene Hubbard! They were real men. Truly there were giants in those days, as well as now, and these giants were not a bit alike. They were extreme in their difference from each other. There is much to justify the generalization that fundamentally Gardiner Greene Hubbard was in the conditions of his time and in fact a radical, and that Thomas Sanders was a conservative, despite all that comes to mind to the contrary. This is signally illustrated in the men to whom they gave way. It was the conservative Thomas Sanders that compelled the evacuation, taking his own departure with it. There is a letter he wrote to Mr. Hubbard in which he plainly stated that in order to interest the money necessary for the further development of the telephone business both of them, Mr. Sanders and Mr. Hubbard, must yield the control of the board to new men. Through Thomas Sanders there came into telephone affairs George L. Bradley and Charles M. Bradley, and through them came in the old, conservative, financially solid Boston family of the Forbes, in the person of William H. Forbes. Old John Murray Forbes of the East India trade said No, he would not go into anything new, but he had no objection to Will's taking hold of the telephone if he wanted to. So William H. Forbes, the son of John Murray Forbes and the son-in-law of Ralph Waldo Emerson, became the President of the National Bell Telephone Company in March, 1879.

But if from the point of view of the Boston of the 70's and 80's Gardiner Greene Hubbard was a radical and Thomas Sanders was a conservative, that kind of radicalism was not outdone and ended by the accession of the Forbes interests. A year before, Mr. Hubbard

had laid eyes on a man in the United States Railway Mail Service in Washington. He made up his mind that that was the man to develop the telephone as a business. Although Mr. Hubbard frankly told the man that he could not guarantee payment of the salary of $3,000 a year offered him as General Manager of the Bell Company, the man accepted, "only asking in addition a reasonable assurance of permanency." For Theodore N. Vail was a man of vision no less than Gardiner G. Hubbard, and he saw the validity of Mr. Hubbard's visions. Far-seeing, abrupt, masterly, he too could see to the horizon, and fortunately he could always find the money too.

Truly, as is often the case, with Thomas Sanders and Gardiner Greene Hubbard, their greatest services were not what they themselves did, but what they did for the continuance of the work after them. Thomas Sanders brought in William H. Forbes, and Gardiner Greene Hubbard brought in Theodore N. Vail. These two, working together, took the telephone from Sanders and Hubbard in New England and made it a national institution.

W. C. Langdon.

Abstracts of Recent Technical Papers from Bell System Sources

Permalloy, a New Magnetic Material of Very High Permeability,[1] by H. D. Arnold and G. W. Elmen. The magnetic alloy described in this paper is a composition of about 78.5% nickel and 21.5% iron and at magnetizing fields in the neighborhood of .04 gauss and with proper treatment has a permeability running as high as 90,000. This is about 200 times as great as the permeability of the best iron for these low magnetizing fields. This high permeability is attendant upon proper heat treatment and also upon other factors among which is freedom from elastic strain. The presence of other elements than iron or nickel and specially carbon, reduces the permeability, but slight variations in heat treatment produce large changes compared with those due to small quantities of impurities.

So far as discovered, other physical properties show no peculiarities at the composition which brings out the remarkable magnetic properties of permalloy. The equilibrium diagram, electric conductivity, crystal structure, mean spacing between adjacent atom centers and density are among the physical properties which have been studied.

To the engineer in electrical communication the development of permalloy is very significant. It assures a revolutionary change in submarine cable construction and operation and promises equally important advances in many other fields.

The Crystal Structure of Quartz,[2] by L. W. McKeehan. Photographs by the powder method of X-ray crystal analysis have confirmed the space-lattice proposed for quartz by the Braggs and others. A careful study of 30 possible arrangements has shown that the arrangement

[1]Published in the Journal of the Franklin Institute, May, 1923; also in the Bell System Technical Journal, July, 1923.

[2]Physical Review, Vol. 21, pp. 503–508, May, 1923.

of atoms which best accounts for the observed intensities of the lines in the photographs differs somewhat from those previously proposed, maintaining more clearly the identity of the molecule SiO_2. These molecules appear therefore to be obtuse-angled isosceles triangles the angle at the silicon atom-center being 115°.2, and the distance between silicon and oxygen atom-centers being 1.631×10^{-8} cm. These molecules lie flat in the basal planes of three interpenetrating hexagonal space-lattices, so that the crystal may be considered as built up of layers of molecules, much closer together than are the adjacent molecules in each layer.

Telephone Equipment for Long Cable Circuits,[3] by Charles S. Demarest. This paper describes some of the important developments in telephone apparatus and equipment which have been brought about by the engineering of long toll cables. The large number of equipment units per station in the cable plant and the greater number of stations in a given length of cable than in an open-wire system have made the economic importance of the equipment design such that a comprehensive program of development, affecting many types of equipment, has been undertaken. The outstanding features of some of the more important of these, including the telephone repeater equipment, test board equipment and signaling equipment, are described. The necessity for compactness in the dimensions of equipment units, uniformity in assembly arrangements, and simplicity in design, together with the need of careful correlation of the electrical and mechanical requirements, are emphasized. The methods proposed for meeting these requirements, generally, are described.

A Determination of the Coefficient of Slip of Surfaces in Air,[4] by Leland Johnson Stacy. In 1860, Maxwell, while working on the mathematical theory of gases, obtained an expression for the coefficient of viscosity

[3]Presented before A. I. E. E., June 27, 1923. Published in the Bell System Technical Journal, Vol. II, July, 1923.

[4]Physical Review, March, 1923.

which was independent of pressure. This paradoxial result was found to be true except for low pressures. It was subsequently shown that this discrepancy was due to the gas slipping along the surface of the apparatus used in measuring viscosity. The author has measured this coefficient of slip for both rough and smooth surfaces. He has used a constant deflection method by which a hollow rotating cylinder produces a torque on a smaller stationary concentric cylinder by virtue of the viscosity of the gas between the two. From a knowledge of the torque, speed and the dimensions of the cylinders, the coefficient of viscosity can be computed. The coefficient of slip can be determined from the values of viscosity at two pressures. The results for shellac surfaces are in close agreement with those obtained from the correction to Stokes law obtained from falling shellac drops.

The Scattering of Electrons by Positive Nuclei,[5] by C. Davisson. The simple theory of atomic scattering developed by Rutherford and verified by Geiger and Marsden is given and discussed. This is then extended by assuming that the mass of the electron varies with velocity in accordance with the relativity mechanics. This results in distribution patterns which depart considerably from those computed by the simple theory. Semi-graphical methods are developed for constructing such distribution curves. When a second extension is made by taking account of the mutual energy of the electrons and nucleus as suggested by H. A. Wilson, the scattering patterns conform more closely to those calculated from the simple theory.

Radio Extension of the Telephone System to Ships at Sea,[6] by H. W. Nichols and Lloyd Espenschied. The paper describes the development of a two-way radiotelephone system and its use in extending the Bell Telephone System to connect with ships at sea. The elec-

[5]Physical Review, June, 1923.

[6]Presented before the Institute of Radio Engineers, New York, January 3, 1923. Reprinted in the Bell System Technical Journal, July, 1923, with minor changes from the Procd. of Institute of Radio Engineers, June, 1923.

trical considerations and the experimental work involved in determining the system-design of the radio link are discussed. Two land stations were established, one of them a permanent three-channel station on the New Jersey coast. Two coastal vessels and finally one trans-Atlantic liner were equipped. These installations are briefly described in the paper.

The operation of the combined radio and wire system is explained, particularly in respect to the transmission characteristics of the over-all system and the effect thereupon of the movement of the vessel and of variations in atmospheric conditions. Measurements of the variations in the field strength received from vessels at sea show why it is possible to receive over very long distances at favorable times at night and not during the day. The method of establishing combined radio-telephone-wire circuits to ships is described and representative results are given of the considerable telephone traffic which was handled over the system experimentally during a period of trial operation. Tests of multi-channel telephone operation to several ships through the Deal Beach shore station, and also tests of simultaneous telegraph and telephone operation from the same vessel are described. Connection of a vessel thru the transcontinental telephone line to the Catalina Island radiotelephone system, whereby the vessel in the Atlantic talked with an island in the Pacific, is briefly described, and finally the outstanding conclusions of the entire development work are given.

Machine Switching Telephone System for Large Metropolitan Areas,[7] by E. B. Craft, L. F. Morehouse and H. P. Charlesworth. From the earliest forms of telephone switchboards to the modern types, the development of the switchboard has been marked by the increasing use of automatic methods to supplement the

[7]Bell System Technical Journal, Vol. II, April, 1923. Presented at the Mid-winter Convention of the A. I. E. E., Feb., 1923, and published in the Journal of A. I. E. E., Apr., 1923.

manual operation wherever this would result in better service to the public or more efficient operation.

In addition to all that has been done in developing and introducing automatic operations with manual switchboards, it has been found desirable and practicable to go further in the direction of introducing automatic operation in the telephone plant and a machine switching system has been developed in which the bulk of the connections are established without the aid of an operator.

The complexity of a large metropolitan area and the exacting requirements which a machine switching system must meet are outlined briefly, and the system which has been developed to meet these requirements is described.

The application of the system to a typical large metropolitan area and the means provided for permitting its gradual introduction into the existing plant are discussed.

Transient Oscillations in Electric Wave-Filters,[8] by John R. Carson and Otto J. Zobel. This paper gives the results of theoretical study of the behavior of electric filters in the transient state. It is found that the remarkable selective characteristics of filters are peculiarly properties of the steady state and become sharply defined only as the steady state is approached. To this fact the authors ascribe the uniform failure of filters to suppress irregular and transient interference, such as the "static" encountered in radio communication, with anything like the degree with which they discriminate against the steady state currents lying outside the transmission range. This limitation is common to all types of selective networks and restricts the amount of protection it is possible to secure from transient interference. The general conclusions reached are applicable to all types of selective circuits.

The following are the main divisions of the paper:

1. The indicial admittances of a representative set of wave-filters.

[8]Bell System Technical Journal, Vol. II, July, 1923.

2. The mode in which the steady-state is built up after a sinusoidal voltage within the frequency transmission range is applied to the wave-filter.

3. The character and duration of the transient current when a sinusoidal voltage outside the frequency transmission range is applied to the filter.

4. The energy which penetrates through selective circuits from random interference.

Use of Labor-Saving Apparatus in Outside Plant Construction Work,[9] by J. N. Kirk. This paper completes a discussion, the first installment of which was reviewed in the BELL TELEPHONE QUARTERLY for April, 1923. The present article describes some of the more important applications of various types of labor-saving machinery to outside plant construction. Among the labor devices discussed are different types of derricks, trailers, earth-boring machines, air-compressors and compressed air tools. Figures are also given showing the savings resulting over manual methods of carrying out similar operations.

A Method of Graphical Analysis,[10] by Helene C. Bateman. In connection with many telephone problems of an economic character, it is necessary to develop methods for making estimates and forecasts of the effects of changes in conditions. When the changes in conditions are such that direct experimentation is impracticable the development of logical methods and bases for estimates involves analyses of past experience in specific situations and, in so far as is feasible, the generalization of such experience. This paper describes briefly a graphical method by which complex economic data may be generalized for use in forecasting probable future conditions.

Simultaneous Color Measurements of Illuminants by Trichromatic and Monochromatic Analysis,[11] by Herbert E. Ives. This paper describes simultaneous measurements made by

[9]Bell System Technical Journal, Vol. II, July, 1923.
[10]Bell System Technical Journal, Vol. II, July, 1923.
[11]Optical Society of America; vol. 4, No. 4, April, 1923.

two methods of color measurement, the trichromatic and the monochromatic. A previous paper by the same author* was devoted to developing the mathematical transformations necessary for expressing measurements made by one method in terms of the other. These transformation methods are based on rather meager experimental data and it was thought desirable to test by experiments, how accurately the actual transformations from one system to another might be made.

The different colors selected for measurement were a series of artificial illuminants and the measurements were carried out by means of a color match photometer previously described**, which permitted all the measurements to be made at the condition of color match.

The results of the measurements are given in tabular form. In general it is found that the agreement between the two methods, using the transformation equations and available data is not very satisfactory. The opinion which was expressed in the development of the transformation methods that new fundamental color mixture data should be obtained before reliance can be placed on the transformation methods is confirmed.

*Journal of the Franklin Institute, January, 1923, p. 23.
**Journal of the Optical Society, March, 1923.

Notes on Recent Occurrences

AN EXPRESSION FROM PRESIDENT HARDING

IT was the great privilege of the Bell System to provide for the late President on his trip to Alaska facilities for keeping in telephone communication with the national Capitol, and for addressing more easily and widely his fellow countrymen through the public address system and radio broadcasting.

We are all gratified that these arrangements lessened the burden of the Chief Executive's last few weeks of life.

A telegram sent by President Harding to H. B. Thayer, President of The American Telephone and Telegraph Company, from Salt Lake City shows that President Harding was not unmindful of these arrangements. In it he said, "I wish to express my great appreciation of the splendid service we have had through the electrical equipment of the Presidential train. I gather that it was more or less experimental from your viewpoint and as the chief beneficiary of it I desire you to know how vastly it has lessened the burdens of a difficult trip. When opportunity is afforded I wish to make a more adequate acknowledgement than this."

The Bell System engineers detailed to the Presidential train received a personal compliment in an invitation to accompany the President to Alaska. The telegram of invitation read as follows:

> "The President would be very pleased if Messrs. Truesdell, Maloy and Santee of your Company could accompany the party to Alaska on the transport Henderson. Entire party feel deep obligation for their services and would be glad if you care to authorize them to take the trip. Reservations have been made for them subject to your approval of the trip. Thank you."

The engineers referred to are: J. G. Truesdell, Radio Broadcasting Department, American Telephone and

Telegraph Company; J. P. Maloy, Long Lines Department, American Telephone and Telegraph Company; H. B. Santee, Loud Speaker Department, Western Electric Company.

CATALINA RADIO TELEPHONE SYSTEM SUPERSEDED BY SUBMARINE CABLE

THE radio telephone system which for the past three years has connected the Island of Santa Catalina with the rest of the Bell Telephone System was closed down on August first. An enlarged service to the Island is now being given over two submarine telephone cables, which were laid to the Island a few weeks before the closing of the radio.

The passing of this radio system is of more than usual interest, both from an historical and a technical standpoint. It was the first, and so far as known, the only radio telephone system which has ever given a commercial telephone service, meeting in both transmission and signaling (although not as regards secrecy or economy) the ordinary requirements of wire telephone circuits.

The system was originally installed because, under the conditions at that time, it was the only form of communication which could be established to the Island without considerable delay. Its three years of reliable service, combined with the large volume of traffic handled over it, are an ample demonstration of the success with which the system met the requirements of commercial operation. When the time came, however, to enlarge the service to the Island, the radio system had to give way, as its annual charge was very much greater than that of a cable circuit of the type now employed.

The radio system, however, would have been kept in service for a few months longer as an extra circuit during the summer season if the governmental authorities supervising radio had not ordered the service termi-

nated, so that the wave lengths which it employed could be made available for broadcasting purposes. This matter of wave length was discussed in connection with the "Second National Radio Conference" in the BELL TELEPHONE QUARTERLY for April. The Catalina system operated on wave lengths between 300 and 500 meters. The advent of radio broadcasting has so greatly increased the demand for wave lengths that there appears to be no space in the ether for a service of this kind anywhere in the range of wave lengths which are now used practically.

It is to be expected that radio wave lengths considerably shorter than those now employed will be made commercially available in the future, and the question will then again arise as to whether radio can be made to economically take care of cases such as this in which it is necessary to bridge moderate length water gaps. There will still remain the difficulty, however, of putting the radio system on a sufficiently low annual charge to compare with submarine cable, and also it may be that the need for radio wave lengths, in order to care for services for which wires are not available, such as to moving vessels, airships and land vehicles, will have developed to such an extent by that time as to again leave no available wave lengths for situations such as this.

A paper on the construction and operation of the Catalina System was published in the Proceedings of the Institute of Radio Engineers for December, 1921. There are a number of technical matters in connection with the system which have not been generally appreciated, and which are worth mentioning here.

The system was provided with a duplex radio telegraph circuit superimposed upon the telephone circuit. In the telegraph circuit a 5,000 cycle current, broken up into dots and dashes, was combined with the voice currents, and together with them modulated upon the radio frequency carrier currents at the sending end. At the receiving end the telephone and telegraph were de-

tected together, and then separated out by electrical filters, taking advantage of their different frequencies.

As a result of using the "dispatch" method of operation over the circuit, something of a record for the handling of messages was made with it. On occasions over 200 conversations were completed over it within a single day.

The system of reception employed gave an unusually high degree of "selectivity," that is, ability to cut out interference from other stations. This was obtained by an "intermediate frequency" form of reception in which the incoming waves were "beaten" down in frequency to about 50,000 cycles, at which point they could be very sharply selected from other frequencies by the means of filter circuits. After filtering, the final detection and amplification of the signals was carried out.

Some six weeks before the radio was taken out of service, a "privacy" system was installed in connection with it. In this system the transmission was sent out in such form that the ordinary radio receiving sets could not pick up the messages and convert them into understandable speech. The system was not "secret" in the sense that one familiar with the methods used could not construct a set which could listen to it. Such a set, however, would be much more complicated than the ordinary set, and the added complication would be of no value except for picking up transmission over the system. It gave a degree of privacy, therefore, something comparable to that obtained by a lock and key, which may not prevent a property from being broken into, but which does, in general, furnish a high degree of privacy to it.

DR. H. W. NICHOLS WINS FAHIE PREMIUM

DR. H. W. Nichols of the Western Electric Company, has been awarded the Fahie Premium by the Institute of Electrical Engineers of London for his recent

lecture, before the Institute, on transatlantic wireless telephony.

Dr. Nichols, who was one of the Company's representatives in London last January during the demonstration of transatlantic telephony, is in charge of wireless research in the Bell System Research laboratories.

DR. F. B. JEWETT ADDRESSES PACIFIC COAST MEETING OF THE A. I. E. E. FROM NEW YORK

ON October 4th, the Pacific Coast Convention of the American Institute of Electrical Engineers met in Del Monte, California, to confer the Edison Medal, and as President of the Institute at the time the award was made, it was the duty of Dr. F. B. Jewett to make the presentation speech. The medalist this year is Professor R. A. Millikan of the California Institute of Technology. As Dr. Jewett was unable to leave New York, arrangements were made to transmit his speech over the transcontinental telephone line. The Pacific Telephone and Telegraph Company installed loud speaking equipment at Del Monte so that the entire convention could hear the speech.

The Edison medal is the highest honor which the Institute of Electrical Engineers can confer and Dr. Jewett, in referring to the medalist, said in part:

"Although Professor Millikan's claim to recognition rests particularly on his experimental work, there are two other classes of achievement for which we here in America are greatly indebted to him. One of these is his work during the war and in the formation of the National Research Council, and the other is his influence as a producer of men."